POWER PLANT ENGINEERING

Established Over 33 Years

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The Charge of the Night Brigade

Darkness to right of them,
Darkness to left of them,
Darkness to rear of them,
Eddied and floundered.
But in the flood light's glow
How that old job did go!
Into the work they dashed,
Making the concrete flow.
Nobody blundered.

NIGHT WORK generally is unpleasant and expensive but at times it is necessary, so we have Knights of Industry who spend nights in industry.

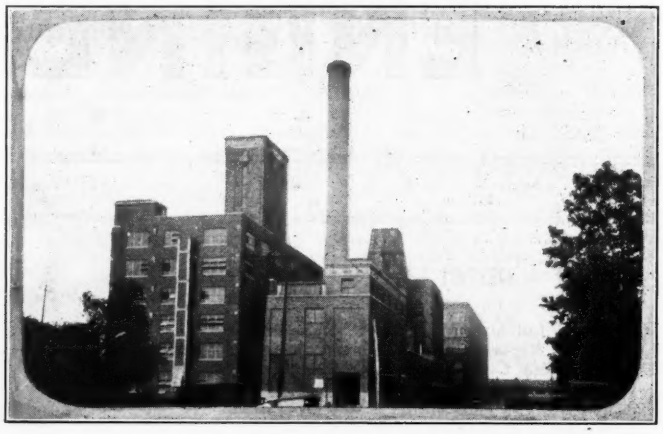
Poor illumination is one of the causes of increased cost of night work and the illustration above shows how this was avoided by the use of portable acetylene flood lights. Good illumination here made the worker's work light.

Pep, as well as good lighting, was characteristic of the night work that was required in completely modernizing the W. T. Rawleigh power plant which is described in the leading article of this issue. Why should not the Rawleigh worker have plenty of ginger? This plant manufactures spices of high quality.

Excellent analysis and careful planning were also characteristic of the night work done and the result was that the changes needed were accomplished without excessive cost, notwithstanding it had to be done at night or other off time, since shutting down the manufacturing plant at any time could not be permitted.

Other difficulties experienced in making the change, due to restricted space and other limitations, also the means used to overcome them, together with new methods and devices used in this industrial power plant, are also described.

Industrial Plant *Shows* Central Station Influence



MODERN EQUIPMENT AND EFFICIENT CONTROLS SUPPLANT OLD AND INADEQUATE EQUIPMENT IN POWER PLANT OF W. T. RAWLEIGH CO. AT FREEPORT, ILL.

ALTHOUGH REFINEMENT cannot economically be applied in the same measure to industrial plants as to large central stations and although standardization cannot be carried out to the degree possible in central station practice because of the greater variety of operating conditions peculiar to industrial plants, there are many methods, devices and types of equipment now used in modern, efficient central stations that may be adapted with success to industrial conditions.

CHANGES MADE WITHOUT PRODUCTION INTERFERENCE

With this in mind and after careful analysis of the economic as well as operating problems involved, Wm. J. Neely, the chief engineer of the W. T. Rawleigh Co., who was its consulting engineer at the time betterment operations were started, planned a process of eliminating old equipment and replacing these with modern equipment of central station type. Changes in equipment were made from time to time without shutting down power or otherwise interfering with production of the Good Health Products made in the factory.

Because of the necessity of maintaining production in the factory, the substitution of new for old equipment and the addition of refinement devices were particularly difficult. Careful planning and scheduling of operations were therefore required and considerable time was required to complete the change. Although the factory, in which medicinal and food products are produced, operated only 9 hr. a day, a plant in which all the glass bottles required for its product are manufactured must operate continuously.

Because of the change from 150-lb. saturated steam as formerly used, to 175-lb., 100-deg. superheat steam which represents a total of 475 deg. change in working temperature and hence necessitated a change in all valves and fittings in the high-pressure lines, the addition of the superheater to the 625-hp. boiler and the installation of the new Westinghouse 1000-kw. turbine were accomplished under difficult operating conditions. The bottle plant had been put into operation on a 24-hr., 7-day schedule, using the engines and the inverted motor-generator set to carry the load. Not having auxiliary steam headers, it was necessary carefully to

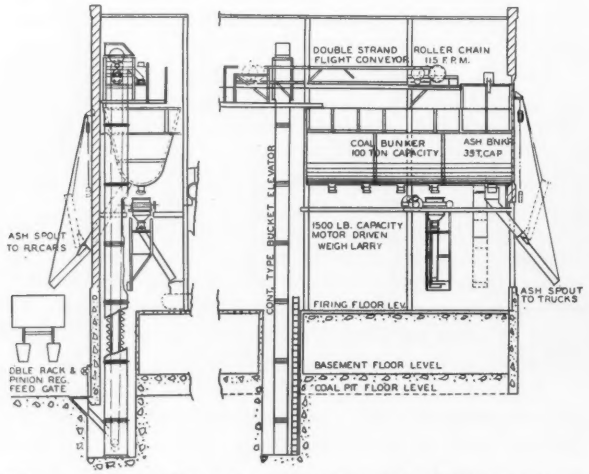

DOUBLE STRAND FLIGHT CONVEYOR
ROLLER CHAIN 115 F.P.M.
COAL BUNKER 100 TON CAPACITY
ASH BNKR 33T. CAP
1500 LB. CAPACITY MOTOR DRIVEN WEIGH LARRY
CONT. TYPE BUCKET ELEVATOR
ASH SPOUT TO RR CARS
ASH SPOUT TO TRUCKS
FIRING FLOOR LEV.
BASEMENT FLOOR LEVEL
COAL PIT FLOOR LEVEL
DBLE RACK & PINION REG. FEED GATE

FIG. 1. COAL AND ASH STORAGE AND FREEMAN-RIFF CONVEYING AND HANDLING APPARATUS

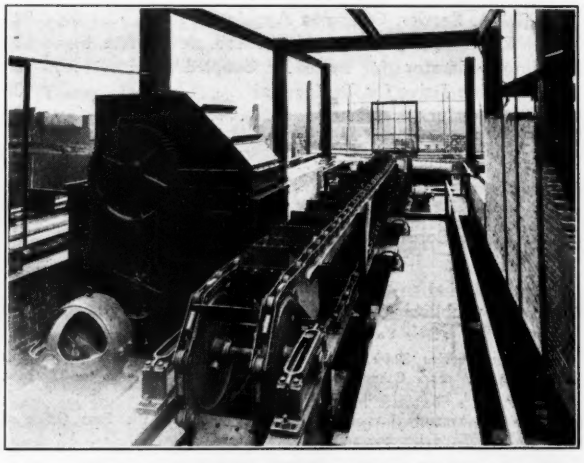


FIG. 2. STEEL FLIGHT CONVEYOR DISTRIBUTES COAL IN BUNKER

schedule the change-over time and accomplish the work in intervals of about 4 hr. each Sunday.

Fine Building for New and Enlarged Plant

Space for operations required in the change was provided by the construction of the fine power plant building shown at the right foreground of the illustration in the headpiece of this article. This building provides a space 80 by 40 ft. for the engine room and 120 by 40 ft. for the boiler room. The walls are of glazed brown brick and the concrete floor is covered with Temoze, a coating which gives it a marble appearance. Ample natural lighting is provided, principally on the long side, by steel sash construction. The skylights in the roof, which is of monitor construction, are of remote control and provide excellent ventilation.

Artificial lighting of the engine room is provided by the installation of eight 500-watt lights; the boiler room is lighted by four 200-w. lights along the front wall, six 100-w. lights on the side wall and three 200-w. lights on the ceiling.

Two 400-hp. Connelly water-tube boilers were first installed. Later, a 625-hp. boiler of the same make was added. Space has been reserved for later addition of another 625-hp. boiler. Steam is carried at 175 lb. pressure and superheated 100 deg. in superheaters furnished by The Superheat Co. Steam at 200 per cent rating, which can be carried easily, is furnished by the large boiler at the rate of 35,500 lb. per hr. and by each of the smaller boilers at 24,000 lb. per hr.

Uniform Superheating

As shown in Fig. 4, the superheater unit extends downwardly between the circulating tubes and into the triangular space between the first and second banks of the boiler tubes. The headers and unit joints are located outside the boiler setting above the first drum. Saturated steam enters the saturated steam header at one side of the boiler and then makes a single pass through the superheater units arranged as multiple loops in parallel and into the superheated steam header, the outlet of which is on the side of the boiler opposite to the saturated steam inlet. The shape of the units causes the steam to travel back and forth several times through the hot gas zone, thus insuring uniformity of superheat.

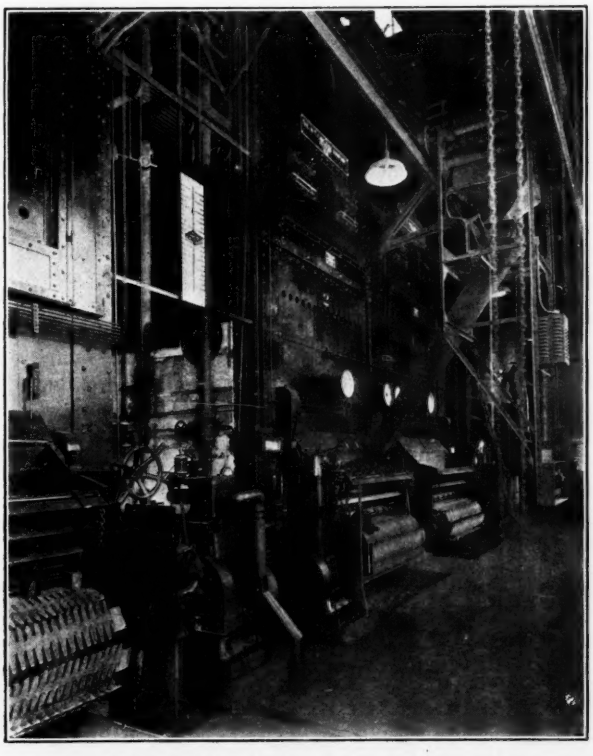


FIG. 3. BOILER FRONT LOOKING TOWARD ENGINE ROOM SHOWING CRAIG COMBUSTION CONTROL INDICATOR

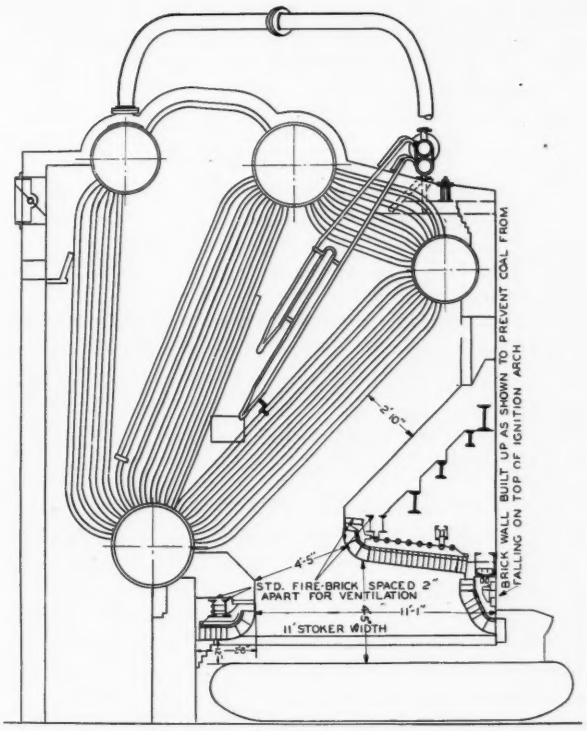

2'-10"
4'-5"
STD. FIRE-BRICK SPACED 2" APART FOR VENTILATION
11'-1"
11' STOKER WIDTH
BRICK WALL BUILT UP AS SHOWN TO PREVENT COAL FROM FALLING ON TOP OF IGNITION ARCH

FIG. 4. CROSS-SECTION OF CONNELLY BOILER SHOWING HARRINGTON STOKER AND DETRICK ARCH CONSTRUCTION

These boilers are fitted with Harrington chain grate stokers, the sides of which were provided with air seals in order to prevent air from short-circuiting the fuel bed at these points, resulting in improved combustion. All boilers are insulated with 4-in. thick nonpareil block.

Franklin County 1¼-in. screenings and yard dust, obtained from coal yards in town, is burned as fuel. Coal, received in a pit from railroad cars, flows by gravity to a 20 by 8 by 11½-in. continuous type bucket elevator which is approximately 56 ft. high and which is driven by a 10-hp. motor. It then passes to an 8 by 13½-in. double strand, roller chain, steel flight conveyor which originally was 32 ft. but now is 71 ft. 9 in. between centers. This conveyor distributes the coal in the steel suspension type coal bunkers which are arranged for storing coal and ash. This bunker is built of ¼-in. thick steel plate.

Originally, this bunker was 36 ft. long but later it was extended to 74 ft., 67 ft. being provided for coal and 7 ft. for ash storage and giving an ultimate capacity of 240 t. of coal and 32 t. of ash. The bunker is equipped with 12 by 12-in. duplex undercut type cast-

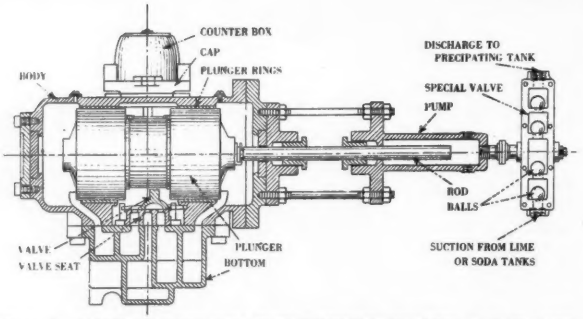


FIG. 5. DEVICE FOR PROPORTIONING WATER, LIME AND SODA FOR WATER TREATMENT

iron discharge gates for coal, one 18 by 18-in. duplex undercut-type cast-iron discharge gate and one 18 by 18-in. overcut steel discharge gate for ash. A dust collector attached to the ash conveyor vents the ash bunker.

Ash Handled by Jet Conveyor

Dustless ejection of ash from the bunker is accomplished by the use of water spray, a line being run direct from the boiler feedwater. The high temperature and pressure aid in penetrating the ash during removal. One end of the bunker was partitioned off to form the storage bin for ash which is handled by means of a steam jet ash conveyor. This ash bunker was located at the far end in the original installation and then moved to the far end again when the bunker was extended so that ash may be discharged from it through chutes either to a railroad car at the side or to a motor truck at the end of the building. The inside of the coal bunker portion is painted with a bitumastic paint to protect the metal against corrosion while the inside of the ash bunker section is lined with concrete laid on reënforcing wire mesh attached to the sides of the bunker by means of angle iron clips. Reserve storage is provided in a pit adjacent to the power plant. This pit which is covered with boards will hold 1800 t. of coal.

Coal drops from the bunker to a 1500-lb. capacity, motor-propelled, weighing larry complete with ticket recording type scale. This weigh larry is floor-operated by means of a drum type controller. The coal is then fed to the stoker hoppers through chutes. Coal may be handled with this equipment at the rate of 45 t. an hour. It will be noted by reference to Figs. 1 and 2 that the motor, drive machinery and head shaft of the elevator are mounted on a structural steel frame carried down to the building and bunker structure. In this manner, the entire weight of the elevator machinery was taken off of the elevator casing itself, the casing becoming merely a housing and vibration is thus eliminated because of the rigid construction of the frame.

Bucket elevator and flight conveyor motors are equipped with automatic starters and are electrically interlocked so that they must be started in proper sequence, that is, the flight conveyor first and bucket elevator second; moreover, if, for any reason, the flight conveyor motor stops, the bucket elevator motor will also automatically stop. Action of the steam in the jet ash conveyor so breaks up all clinker that a market is readily found for all cinders produced which are sold to building contractors in town for cinder-block.

Detrick flat suspended arches are used in the boiler furnace construction and the boilers are fully equipped with the Craig system of automatic combustion control, all regulators of which are operated by oil pressure which in each case is supplied by a rotary pump direct connected to a ¼-hp. electric motor.

Combustion Control

Regulation of combustion is accomplished by individual regulation as well as by a master regulator for the entire plant. Craig, type D overfired draft regulators, attached to each boiler, control the uptake dampers, holding a constant overfire pressure in each case. A Craig type S master regulator, which functions by the steam pressure, controls the combustion for the entire plant.

This master regulator operates a main jack shaft to which chronometer valves in the steam line to the Carling turbine blowers, are connected, through a spe-

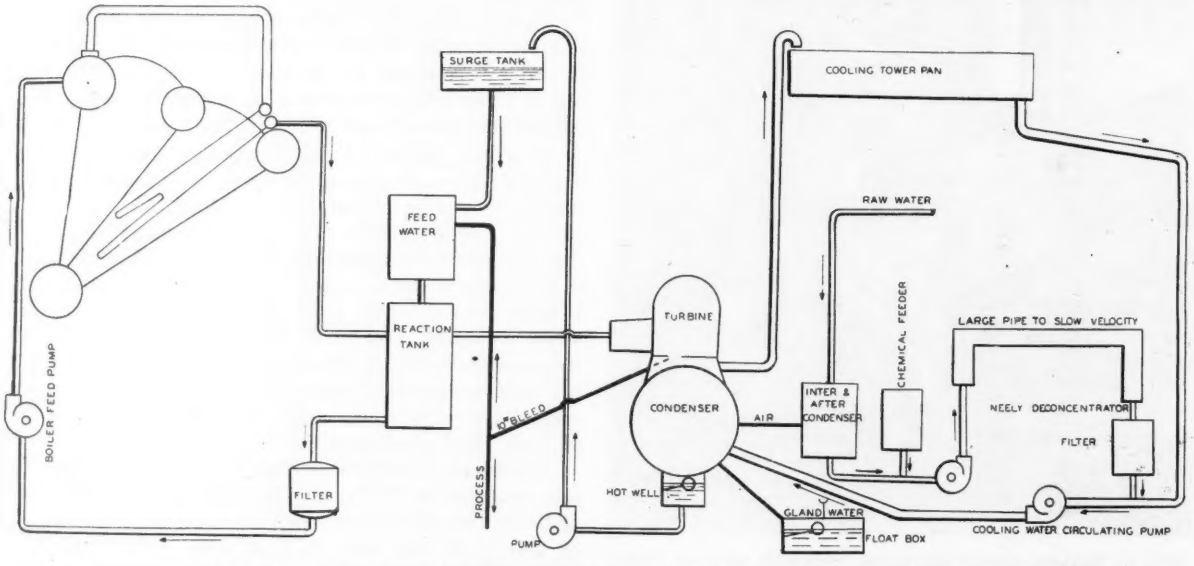


FIG. 6. STEAM FLOW DIAGRAM SHOWING DECONCENTRATING APPARATUS DESIGNED BY MR. NEELY

cial disengaging device. This device allows the apparatus to be taken off automatic operation and placed on hand control merely by pulling a spring loaded pin out of engagement. This is accomplished without disturbing the operation of the various regulators. A special disengaging device of this kind is located at the side of each boiler on each line connected to a turbine blower. In order to insure against shut-downs, a spare turbine blower is provided. This can replace any that may need repair at any time in 35 min.

At the Rawleigh plant, where in one case there are two blowers to a boiler, a chronometer valve is installed in the main steam line ahead of the branch leading to the two blowers and connected to this is one of

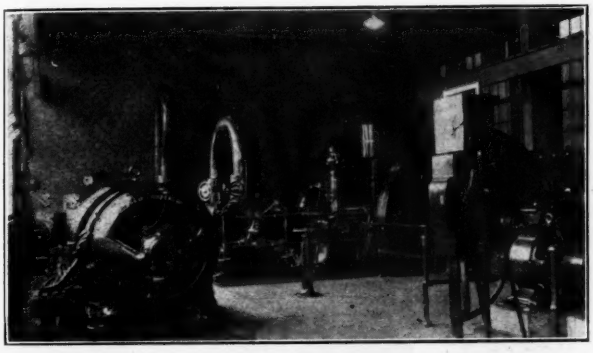


FIG. 7. ONE END OF ENGINE ROOM SHOWING MURRAY CORLISS AND CHUSE ENGINES, ALSO MOTOR-GENERATOR SET

the damper releasing devices already described. There is also a hand-controlling throttle at the turbine blower, allowing for synchronizing the speed of the turbine blowers.

Control of the speed of the stoker engines through a special attachment on the Waters governors is accomplished by the jackshaft operated by the master regulator. The load indicator is also operated by this jack shaft.

Draft Is Balanced

From this, it will be noted that as the steam pressure changes, the master regulator operating the main jackshaft effects a corresponding increase or decrease in the speed of the turbo-blowers as well as of the stoker engines, as the case may be. Such changes are shown on the load indicator. When change of speed of the blowers affects the overfire draft, the Craig type D regulator adjusts the uptake damper so as to maintain the desired constant overfire draft which has been predetermined. Regulation, therefore, balances the draft.

Located in front between the No. 2 and No. 3 boilers, as shown in Fig. 3, the combustion control indicator shows conveniently the condition of operation. The control mechanism proper, which consists principally of a bell float, is located in the rear of the boiler and the circulating unit which supplies oil for the system is located in the basement. Radial brick construction was used by The Heine Co. in building the stack, which is 16 ft. dia. at the breeching, 10 ft. dia. at the top and 165 ft. high.

Boiler Feedwater

Well water obtained from a private well 957 ft. deep is now used for boiler feed makeup. This is pumped by a 600-g.p.m. Worthington "Coniflo" deep well centrifugal pump which has blades at the bottom as well as top of the well. The water is pumped to two supply tanks each holding 30,000 gal. of water about 60 ft. above the top of the building and maintaining a pressure of 65 lb.

Use of city water was abandoned, not so much because of its hardness as for its tendency to fill up the steam lines. Little scale was formed but the line to the pumps formerly filled up so much that the pumps were slowed down. A separate steam line was first piped from the main line to the pumps. Piping around avoided the deposit trouble but the present exclusive use of well water has proven to be the best solution of the trouble. The city water hardness is 29 gr. per gal. while the well water has a hardness of 21.4 gr. per gal. Calcium and magnesium carbonates with a small percentage of magnesium sulphate represent the principal solids found in the water used.

Water comes from the well at an almost uniform temperature of 65 deg. This water is first used as cooling water in the condenser which raises it to 185 deg. and then for makeup. The feed water is raised to 208 deg. in the Vater feedwater heater. All waste water except the jacket water of the air compressor, which, it is expected, will be used also later, is employed.

Gland Water Drains Now Used

Formerly all gland water was wasted to the sewer. In order to use this water, which is valuable as make-up

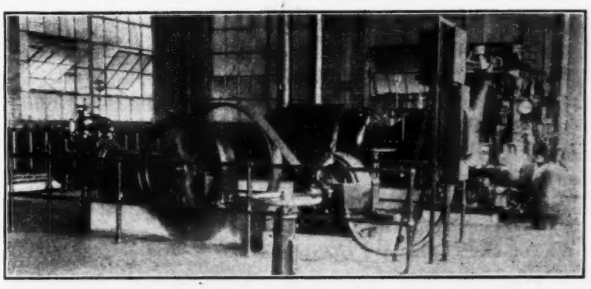


FIG. 8. OTHER END OF ENGINE ROOM SHOWING STEAM TURBINE AND MOTOR-DRIVEN AIR COMPRESSOR

water, a float-box which acted as a sump was installed below the basement floor line and the water drained to it. This float-box was connected by a vacuum pipe to the condenser which is operating under 27 in. of vacuum. When the float-box is full, the float opens up and the vacuum returns the water to the system through the condenser.

To eliminate the spraying of cold water in the vacuum return line which is necessary in most heating systems in order to prevent steam binding and which, in many instances, causes the heater to overflow, the discharge line from the vacuum pump to the heater was tapped and this carried out of doors to a series of coils which act as a cooler. After the condensate is cooled, it is again introduced into the vacuum return for use as spray water. This eliminated the need of using raw water for this purpose and avoided the attendant waste.

All water goes to a sump, located below the basement floor, from which it is drawn by vacuum to the 1650 sq. ft. Westinghouse surface condenser and mixes even-

tually with the condensate. A Westinghouse air ejector is used for air removal. Condenser tubes are cleaned every six weeks. This cleaning is started at 11 p.m. Saturdays. It takes about 4 hr. to clean the 850-⅝-in. dia. by 12-ft. long condenser tubes during which time the steam turbine runs noncondensing. The average vacuum carried is from 27 to 29 in. The condenser is provided with an 1800-g.p.m. centrifugal water circulating pump. A Stocker cooling tower, which is located on the roof, is also provided.

Use of well water and of the deconcentrator not only

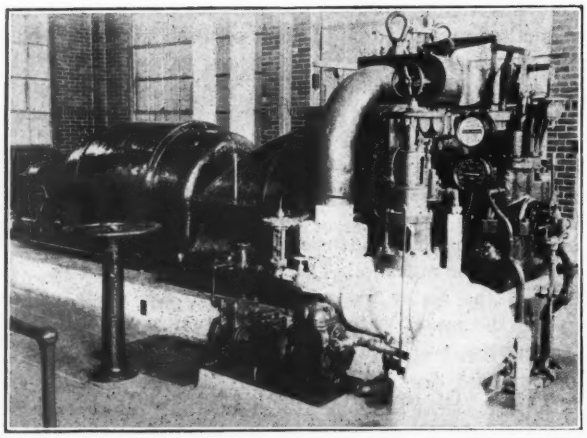


FIG. 9. 1250-HP. WESTINGHOUSE BLEEDER TURBINE-GENERATOR CARRIES MOST OF THE LOAD AT PRESENT TIME

improved operating conditions but have also reduced the cleaning time on the condenser 100 per cent.

Two Worthington duplex and one American-Marsh centrifugal pump operating at 2400 r.p.m. are used for boiler feed service. The latter is driven by a Carling two-velocity-stage impulse type steam turbine. Each boiler is provided with a Copes feedwater regulator.

Water Softening Is Done by the Vater Hot Process

Difficulty was experienced when it was desired to install the water softener, due to the limited amount of space at the only available location. At the far end of the boiler room, as viewed in Fig. 3, had been an old vertical feedwater heater of large storage capacity. This was converted into a reaction and precipitating tank after removal of all internal parts, by replacement with such parts as are necessary in the Vater system. A new Vater heater was placed on top of this converted precipitating tank and connections were made to the necessary lime and soda mixing tanks, pumps, filter and trap.

In this system the proportion of water, lime and soda solutions passed to the heater is regulated by means of a "proportioner" which is built like a duplex pump as shown in Fig. 5. At the ends of each cylinder is a small simple plunger pump which is operated by the movement of its respective proportioner plunger. Lime and soda solutions are drawn from their respective mixing tanks and discharged to the heater through a system of ball check valves. A counter attached to the proportioner indicates the amount of treated water that passes to the boilers. Two sand filters in parallel and provided with arrangements for back washing, receive and clarify the treated water before it passes to the boilers.

Earlier Engine Equipment Held in Reserve

Originally, a 250-hp. Murray Corliss engine was the sole motive power. This was supplemented by a 700-hp. Chuse nonreleasing Corliss engine and recently a 1250-hp. Westinghouse bleeder turbine generator was added. Steam is bled at from 5 to 15 lb., the usual pressure being 10 lb. Direct connected to the Murray Corliss engine is a 150-kw., 250-v., 600-amp. Crocker-Wheeler generator, running at 125 r.p.m. A 400-kw. Crocker-Wheeler generator is direct connected to the Chuse engine. This generates 250-v., 1600-amp. current at 150 r.p.m. Direct connected to the steam turbine is a 1000 kw. Westinghouse alternator to which a 15-kw., 250-v. Westinghouse exciter is direct connected. Generator ventilation is accomplished by the use of air coming from outside of the building and passing through the cellar in order to maintain it at a constant temperature. A 5-kw. exciter installed in the basement is provided for emergency purposes.

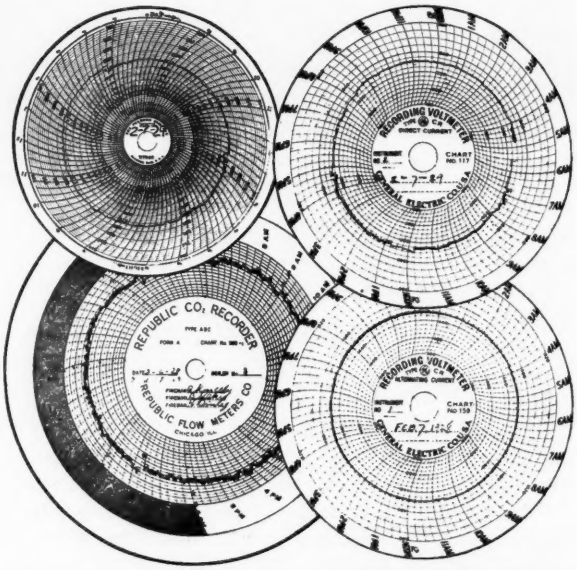


FIG. 10. RECORDING CHARTS SHOWING STEADINESS OF OPERATION. CHART IN UPPER LEFT-HAND CORNER IS THAT OF FOXBORO RECORDING THERMOMETER FOR INDICATING THE TEMPERATURE OF THE GENERATOR WINDINGS

At the present time, the Murray and Chuse units are held in reserve, the latter being kept warmed up at all times ready for operation. Both Murray and Chuse units furnish direct current; the new turbine generator produces alternating current. Originally 220-v. direct current was used but as the plant grew, this was changed to 440 and alternating current electricity was made.

Motor-Generator Acts as Connecting Link

Constant demand for alternating current amounting to about 145 kw. comes from the bottle making plant. Arrangements were therefore provided to supply either direct current or alternating current from any one of the generators, by the use of a 300-kw. Allis-Chalmers motor-generator set which thus becomes the connecting link between the prime movers. If anything happens,

the motor-generator set may be reversed and direct current made from alternating current. This change can be made in 1½ min. Everything is metered by means of a demand meter.

Complete equipment of control instruments and accessories adds much to the refinement which has been experienced. The boilers are supplied with two 2½ in. Yarway blowoff valves and a 4-in. Lunkenheimer safety valve. Strong boiler stop and check valves and two safety valves are supplied to each boiler, the larger boiler being fitted with Lunkenheimer valves while the smaller boilers have Ashton valves. The superheaters are also furnished with safety valves. A complete set of Vulcan, 7-element soot blowers which are used four times in 24 hr. are supplied to each boiler.

Three Republic steam flow meters and CO_2 recorders are on the boiler front. No pyrometer is used but recording thermometers are connected to each of the boiler combustion chambers. Crane pipe fittings and expansion joints were installed. High-pressure fittings are used and all pipe covering, which is of double thickness, was furnished by Keasbey & Mattison Co. High-pressure gate valves were furnished by George B. Limbert Co. and Jenkins low-pressure valves are used and Garlock packing is used for high-pressure steam joints. A Bowser oil filter is provided for the lubricating system. The oil in the turbine is changed twice a year.

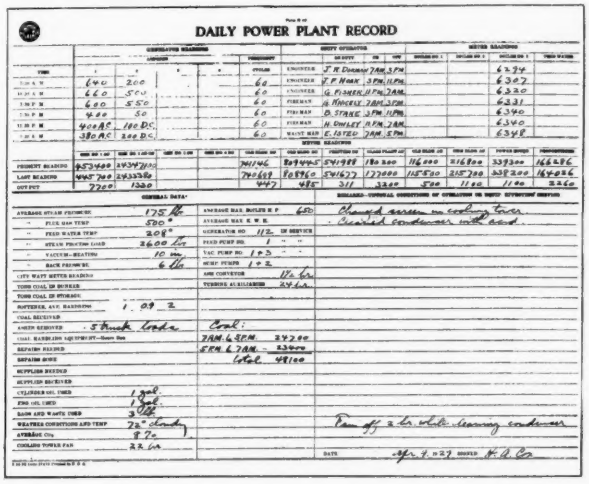

DAILY POWER PLANT RECORD

FIG. 11. DAILY POWER PLANT RECORD

Costs Reduced by Refinement

Due to the better methods used, improved load factor, and better equipment, the power cost is now only about 40 per cent of the former cost. The former load factor was 0.5 while at present it is 0.75.

Improvement in load factor was due to the addition of the bottle making plant which operates on a continuous basis. Before its addition, power was required only nine hours a day, six days a week. Costs as figured, include fixed charges, interest, depreciation, insurance, labor, fuel, supplies and maintenance. Increased output reduced the indirect expenses, hence it aided in reducing costs but the installation of the bleeder turbine added considerably to this cost reduction.

Under present operation, the average evaporation of water is eight pounds per pound of coal. The average summer load is 500 kw. and that during the winter is 700 kw. To facilitate maintenance, a 10-t. Conkey hand-operated crane is provided and extra parts for all engines and generators are carried for emergency use.

N. E. L. A. Reports on High Pressures and Temperatures

Higher steam pressures and temperatures are discussed in a serial report for June, 1929, No. 289-73, just issued by the Prime Movers Committee, Engineering National Section, National Electric Light Association, 420 Lexington Ave., New York, N. Y. According to the report, the past few years have demonstrated the practicability of operation and the thermal economy of the 1200-lb. cycle. This report contains statements on stations that have operated at the above-mentioned pressure for some time and on a number of new installations. It is interesting to note that only a few years ago the Higher Steam Pressures and Temperatures Sub-committee's report included data on 300-lb. and 400-lb. installations, whereas this issue contains nothing below 600 lb., and the majority of data are on installations of 1200 lb. or over. This increased use of higher pressure is due, to a large extent, to the untiring effort of the A. S. M. E. Committee on Steam Research.

Steam temperatures have not kept pace with steam pressures. Temperatures of 650 to 700 deg. F. have been common with 300 and 400-lb. units, whereas 750 to 775 deg. F. seems about the present practical limit for 1200-lb. installations in this country. The possible reason for this is found in a statement on The Behavior of Metals at Elevated Temperatures, submitted by Prof. A. E. White.

Rapid acceptance of the 1200-lb. cycle as economical and practical has opened the way to still higher pressures and a study of their thermal possibilities is not only of interest but quite timely. What the future holds in the design of higher pressure and temperature equipment is well brought out in a statement on Higher Pressures and Temperatures which C. F. Hirshfeld has contributed.

Probable relation of caustic embrittlement to higher pressures and temperatures and the desirable carbonate-sulphate ratios are covered by a statement on The Relation of Embrittlement to Higher Steam Pressures and Temperatures, by Prof. F. G. Straub.

A section of this report contains data on the relative construction costs of 400 and 1200-lb. equipment Manufacturers' statements also are included. The rapid increase in the use of welded vessels for high pressure service is made evident by some of these statements.

Pulverized Fuel Approved in Chicago

With reference to an inquiry as to the attitude of the Department of Smoke Inspection and Abatement of Chicago in regard to installation of pulverized coal burning plants within the city limits, Frank A. Chambers, Deputy Smoke Inspector in Charge, has made the statement that:

"This department approves the use of pulverized coal in boiler installations but requires that some means be provided for the separation of the ash and solids from the products of combustion to the extent that the discharge from the stack does not constitute a nuisance."

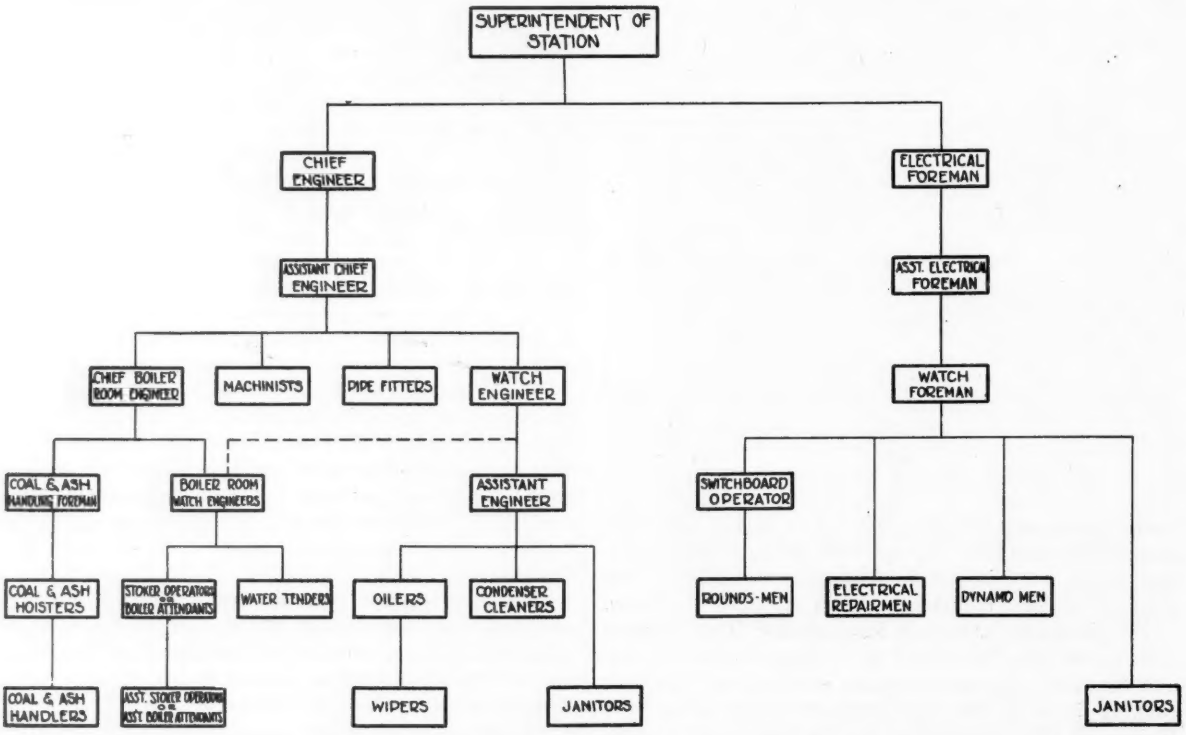
Details of the Organization and Operation of a Large Power Plant

PART I. EFFICIENT PERFORMANCE OF A STATION DEPENDS UPON THE ORGANIZATION, TRAINING AND MORALE OF THE OPERATING FORCE. BY J. C. FALKNER*

AFTER THE GENERATING UNITS, boilers and necessary auxiliaries are installed, the next question is operation. How are they going to be operated? What supervision is required? How many men are necessary to assure safe operation? How may the coal factor be checked? What system of inspection and cleaning shall be installed? How may the morale of the force be kept at its highest pitch? How may the interest of the men be kept on their particular jobs and not let their work be just another day? How will men be stepped up from one class to another? These and many more are the problems that must be carefully handled.

The operating department is handed property worth millions of dollars and told to get busy and produce. The designing engineers have figured out the heat balance and the B.t.u. rate per kilowatt-hour that should be reached. Manufacturers have given, and due to their inability to test the apparatus in their shops, perhaps guessed at, efficiencies that should be met and have computed the gallons of water a pump should deliver. Condensers should give certain performances. Any of this not coming up to expectations can give a great deal of trouble to the operating force.

If a large condenser, pump, or other equipment does not come up to the guarantees, there is not a chance in a thousand that it would be taken out and sent back to the manufacturer. The manufacturer will work on the apparatus affected to try to remedy the defect but all this time your station efficiency is suffering and your daily B.t.u. per kw-hr. curve never shows exactly why it has a high value. The cause of these high rates is forgotten in a year or so when the curves are compared with those of another station.



PROPOSED ORGANIZATION CHART FOR A LARGE POWER PLANT

NEW STATION NEEDS TO BE STUDIED CAREFULLY

To the uninitiated, it would seem easy to go into a new station where everything was of the latest design and highest guaranteed efficiencies and start right in with a B.t.u. per kw-hr. rate somewhere near that expected; this, however, is rarely the case, as the new equipment has many strange characteristics to the operating force, so that only after many trials can the most efficient point be reached.

*Assistant to Research Engineer, New York Edison Co.; Formerly Superintendent, Hudson Avenue Station, Brooklyn Edison Co.

With all of the foregoing points in mind, the writer would build up an organization as illustrated, built up as follows:

A superintendent who would have complete supervision, reporting to the superintendent of operation.

A chief engineer and an electrical foreman, of equal rank, each having supervision over their respective divisions of station personnel and equipment.

Assistant chief engineer, chief boiler room engineer, watch engineers, boiler room watch engineers, assistant electrical foreman, watch foreman, switchboard operators and others shown on the chart, each of whom report to their respective supervisors.

In the absence of the chief and assistant chief engineer, the watch engineer takes charge of the steam end of the station, while the watch foreman takes charge of the electrical end in the absence of the electrical foreman and assistant electrical foreman.

The number of men required to operate a large station varies largely with the design. A station having many floors with the apparatus widely separated will obviously need more men than one having this apparatus conveniently placed. The writer thinks that it is a big mistake to compare different stations on a man-kilowatt basis, as in almost every case costly apparatus cannot be given the attention necessary with a crew cut down to a minimum and almost invariably the maintenance cost will be high when this condition exists.

For a station operating two large units and 8 to 12 boilers, the average number of men is about 200 for the steam division and 60 for the electrical division, with from 5 to 10 per cent added for each additional generating unit with its boilers, auxiliaries and electrical apparatus.

Coal Unloading and Storage Is a Considerable Item

Various phases of operation will be taken in the order they appear in the transfer of energy from the incoming coal to the outgoing electricity.

Coal is brought to the station dock or storage yard in barges, coal ships or in railroad cars. Large ships or barges are easier to unload than smaller ones as less trimming or guiding of the bucket by men in the ship or barge has to be done. Drop bottom cars are ordinarily used when coal is brought by railroads.

Most of the modern coal towers can be moved along a track parallel to the dock, so that a ship or barge need not be moved once it is tied to the dock and this lessens the unloading time. The average tower will hoist approximately 250 to 350 t. per hr. from a loaded barge.

Usually there are two regular hoisters with one or two other men, who hoist approximately an hour per day so as to be ready in an emergency. It takes three or four men to guide the bucket to the sides and corners of a barge or ship during trimming. These men clean up coal spilled on the decks, tie up barges and many odd jobs when not engaged in trimming.

One man is stationed at each coal crusher and two or three men are usually distributed along the coal conveying apparatus, depending on the type used. The coal is hoisted on only the day watch, except in a few stations where the bunker storage or hoisting capacity is small.

From the tower the coal is transferred to the coal bunkers either by belt conveyors, automatic electric cars, cable cars or bucket conveyors. The coal passes over recording scales which register the amount taken into the station. This gives a good check against the bill of lading or the amount of coal charged against the station. The bills of lading have been checked as close as two to three tons when coal was taken from a 1200-t. barge. There is usually considerable loss in coal due to loading and unloading of barges or ships each month that is charged against the station coal factor as having been burned.

If several grades of coal are used, it is best to keep each kind in a separate bunker if possible, unless, as has been found in one station that by mixing a good coal with a poorer grade, better firing conditions were obtained than when burning either separately. In other cases the mixing of coals has resulted in considerable clinker trouble in stoker fired furnaces.

In stoker fired plants, the coal is best delivered by weigh larries to the boilers and a record of weight made on a card before and after each dump into the boiler hopper. These cards are assorted according to the boilers the coal was dumped into and are used in calculating the efficiency of each boiler and the daily coal rate of the station. The cards should be collected every two hours and checked against the power output for those hours, to give the watch engineer a record of the coal used while he was on watch.

Coal Weights Should Be Closely Followed

In addition to the larry weights, revolution counters on the stoker shaft give an indication of the coal fed to each boiler. These counters should be read each half hour and the result checked against a table showing boiler rating expected from a given speed of the stoker. This comparison by the stoker attendant will show him whether he is keeping the fires in good condition or not for efficient operation and will also serve to keep him constantly in touch with the coal rate of each boiler he is attending. It is much harder to see and explain the results of yesterday from charts 24 hr. old than it is at half hour intervals.

With pulverized coal, the checking is much more difficult. In a central system of pulverizing, the raw coal can be weighed going to the mills or it can be weighed by discharging it into a separate weigh tank which is part of the closed system. This coal is then discharged into the boiler bunker by a transport pump connected to the weigh bins. Due to the extra cost of weighing the coal, this latter method will be used only while testing a boiler.

One method that has been used is to calibrate a voltmeter into pounds of coal per hour and connect this across the voltage supply to the feeder motors. This will be subjected to error according to the fineness and dryness of the coal but should give a fairly representative check.

In a unit mill system, the coal should be weighed before going to the mill and accurate checks taken the same as in a stoker plant.

In stoker-fired plants, usually one stoker operator can handle from two to four boilers and one water tender can handle six to eight boilers when automatic combustion control and automatic feedwater regulators, which are regarded as a practical necessity in large

modern plants, are used. One or two stoker helpers or assistant stoker operators are employed to help the stoker operator.

In a pulverized coal plant, one operator should be able to handle two mills, one boiler operator should handle six to eight boilers with an assistant, while one water tender should handle eight boilers with automatic combustion control and automatic feed water regulators.

Boiler Room Now Demands the Best of Help

In most modern plants, boiler meters showing steam flow, air flow and steam temperature are used. These meters are set so that the steam and air pens will be together when the boiler is operating at 14.5, 15 or 15½ per cent CO_2 depending on the percentage desired by the operator. The boiler attendant's job is therefore to regulate his fire so as to carry the desired load on the boiler while still keeping the air pen with the steam pen and the revolutions of the stokers, unit mills or coal feeders at the test results. When the above conditions are met, you are getting the best that can be expected.

Formerly, men were graduated from the boiler room to the turbine or engine room but now the condition is reversed. The variable conditions always to be met in a boiler room, such as physical and chemical peculiarities of coals, sudden changes in load and many other factors that come up daily, demand that only the best of men should be put in the boiler room and every means should be taken to train them for their jobs. A drop or raise in efficiency of one per cent in a large boiler room will run into $15,000 to $20,000 a year.

This does not detract one bit from the importance of the work in the electrical galleries and turbine room as that work is just as necessary as that of the boiler operators and it is just as necessary to act quickly in an emergency but a more stable condition exists during normal operation.

Some form of combustion control should be installed that will control forced and induced draft fans, primary air fans (when using pulverized coal), coal feed, individual dampers to each boiler for forced draft, excess pressure regulators and speed of the boiler feed pumps. These are all regulated by the steam pressure actuating a supermaster regulator, from which each boiler master is controlled. Equal rating on all boilers can be maintained. The regulators taking care of small fluctuations in steam pressure leaves the boiler attendant free to look after the finer details of firing. One man is usually assigned to the job of keeping this combustion control in order.

Sale of Ashes Is a Source of Revenue

In a stoker operated boiler room, the ashes and clinkers are usually removed from the furnace by clinker rolls. The ashes and clinkers falling directly into a sluice way or closed ash pit from which it is sluiced out to large outside ash pit. From this they are periodically loaded into an ash scow or trucks. With this arrangement, two men per watch should handle all the ashes, with a crane operator added while loading the scows or trucks. In stations near large cities, the sale of ashes to contractors usually more than pays the labor for ash handling.

In a pulverized coal plant, the cinders and ash going up through the boiler is from seventy-five to eighty-five per cent of the total refuse, the remainder being collected in the ash pit. The part going up through the boiler is caught by cinder catchers and brought down and sluiced to the outside ash pit. The ashes from the ash pit of each boiler is hoed into a trough and sluiced or pumped to the outside ash pit.

A new method in use in several pulverized coal plants, particularly where the fusing temperature of the ash is low, is to tap the bottom of a specially designed ash pit as if it were a cupola, allowing the molten ash to flow out, then quenching it with a stream of water, the ash breaking up into small particles like grains of sand. This ash is then sluiced to the outside ash pit.

Boiler auxiliaries such as induced draft, forced draft and primary air fans are usually automatically regulated but at least two oilers or fan operators should be on watch to see that everything is running as it should. The soot blowers are usually operated once a day by one of the assistant boiler operators.

In the main steam header and connecting pipe lines, there are usually motor operated valves that can be opened and closed from a push button control at the valve and a remote station for closing any or all of the valves in case of a serious line failure. These valves should be operated every month to see that they function properly.

(To be continued)

Production of coal in Wyoming during 1928 amounted to 6,571,683 net tons, according to a statement just issued by the United States Bureau of Mines, Department of Commerce. In comparison with the 6,753,656 t. produced in 1927, the figures for 1928 show a decrease of 2.8 per cent. The interesting feature of the statement is, however, the high output per man per day that has been attained in Wyoming. Since the introduction of mining machines in the coal fields of Wyoming the average number of tons produced per man-day has been steadily mounting and in 1928 reached 6.34 t. This compares with an average of 4.69 t. a day in 1920 when the first mining machines began to appear in the State. In Sheridan County, Wyoming, which has been particularly amenable to machine mining, the average output per man in 1928 reached the high point of 12.89 t. per day, as against an average of 4.55 t. for all bituminous mines in the United States in 1927. Incidentally, the tonnage produced by mechanical methods in Wyoming in 1928 ranked second only to that of Illinois. Of the 6,572,000 t. produced last year, 2,682,000, or 40.8 per cent, was mined mechanically.

Sulphur tests for the determination of sulphates in boiler scale and sulphur in coal can conveniently be made by means of a blow pipe. The scale should be mixed with charcoal and soda and heated with a reducing flame produced by holding the tip of the blow pipe just outside of the smoky part of the flame from a candle or bunsen burner.

This reducing flame, having a deficiency of oxygen, takes away oxygen from the compound. If sulphur is present as a sulphate, it is reduced to a sulphide, a lump of which placed on a silver coin and moistened leaves a black stain.

Thermal Storage Aids Boiler Plant Operation*

MANY SCHEMES HAVE BEEN DEVEOLPED TO INCREASE THE FLEXIBILITY OF THE MODERN INDUSTRIAL POWER PLANT BY THERMAL STORAGE. BY E. G. PHILLIPS

PROBABLY the chief difficulty of the boiler house engineer, who is continually endeavoring to maintain high thermal efficiencies on industrial plants, is that while the rate of evaporation and also combustion should be practically constant to give the best results, almost all heat loads on such plants are of a very fluctuating character.

If it is agreed that these sudden variations in demand are essential and that they are the cause of low efficiencies of operation, then it is obvious that the steam generating plant is not sufficiently flexible for it to be able to follow the demand and every possible effort must be made either to increase the flexibility of the generators or some scheme must be devised which will enable the curve to be flattened out as much as possible so as to bring the demand within the degree of flexibility that can be reasonably obtained and maintained.

Where the plant is required solely for the production of mechanical energy, then the water tube boiler with pulverized fuel, pre-heated air, induced, forced or balanced draft, etc., are all available for more rapidly following the variations in demand for the steam but for many industries such plant is not available and by many is considered as unsuitable for pure process work calling for large quantities of steam over quite prolonged periods.

It is not my intention to argue that aspect of the question at the present time but rather to draw your attention to a few methods of storing up, what we will term, surplus heat until required and then using it as called upon to the relief of the maximum load on the boilers and furnaces.

Preparation and accumulation of heat in this form should be carried out almost regardless of the actual requirements of the process, but more in accordance with the capacity of the boiler plant. If the peak load curve could be flattened out, while the valleys of the chart were filled in by steaming above the actual requirements and the surplus were used for the preparation of the heated liquids, it will readily be acknowledged that the conditions so produced would tend to greater efficiency in the boiler house and also to greater output in the works where the waiting time would be reduced, consequently the actual operating hours lengthened.

The great amount of publicity that has been given during the last few years to the method of steam accumulation as adopted by Dr. Ruths and his associates[1] makes it unnecessary to detail this system, except to remind you that it is designed to allow of the boilers being steamed at normal capacity continuously and the surplus stored in the form of water at the temperature and pressure of the boiler. In this system, when the demand for steam is greater than the normal steaming rate of the plant, the high pressure and consequently high temperature water re-evaporates and this is used to augment the steam available to the process.

CONSTANT PRESSURE STORAGE ADVISABLE FOR SOME CONDITIONS

This system is, however, only readily adapted to the works requiring two or more pressures, as obviously you cannot re-evaporate the water in which you have accumulated your heat except by reducing the pressure imposed upon such water.

This system is known as a falling or variable pressure system and is not designed to ensure the carrying of a constant steam pressure on the boilers but rather a constant firing condition or constant furnace efficiency.

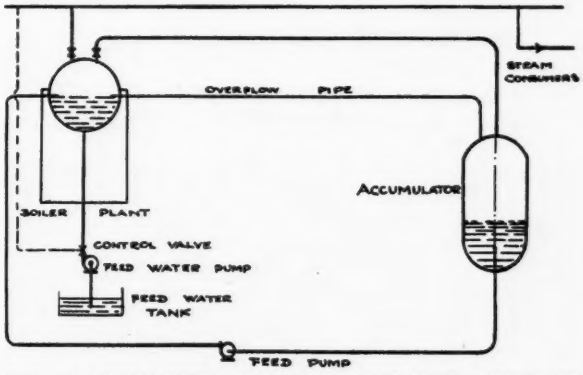


FIG. 1. SIMPLIFIED DIAGRAM OF THE KEISSELBACK SYSTEM OF CONSTANT PRESSURE ACCUMULATOR OR THERMAL STORAGE

In this method of thermal storage, the accumulator shells have to be of considerable dimensions as they must contain sufficient water to condense all the surplus incoming steam and as the heat is again recovered as vapor, the heat content of the vast bulk of water cannot be recovered below the temperature of the secondary steam pressure.

When this type of accumulator is "empty," it has necessarily a huge bulk of high temperature water which cannot be released to augment or assist the boiler load if a "peak" is still being sustained.

CONSTANT PRESSURE SYSTEMS

In many industries, the advantages of the falling or variable pressure accumulator cannot be utilized and for such one pressure plants, the constant pressure methods possess distinct advantages. One of these is the Keisselbach System, which consists primarily of a storage tank in which water is accumulated and maintained at both boiler temperature and pressure. This accumulator is in direct contact with the water in the boiler and is circulated from the boiler to the accumulator and from this storage vessel back to the boiler by means of a circulating pump.

The normal feedwater pump is controlled by a pres-

*Paper read before the Institution of Heating and Ventilating Engineers.

[1]See page 400, April 1, 1929 issue of Power Plant Engineering.

sure-operated regulator which slows down or even stops the pump as the pressure falls, and speeds up again and accelerates above normal, due to a rise in boiler pressure.

A pressure equilibrium pipe admits steam from the boiler on to the top of the water in the accumulator and ensures that the accumulated water is maintained at boiler pressure and temperature. The location of the water pipe feeding the accumulator is such that it acts as an overflow pipe and thereby maintains a constant water level in the boiler, which cannot be exceeded due to this connection. Figure 1 will indicate the simplicity of the system and give a ready conception of the theory of operation which is roughly as follows:

Assume the plant to be in normal operation with water at the correct level in the boiler and the accumulator, say, half full and the circulating pump running

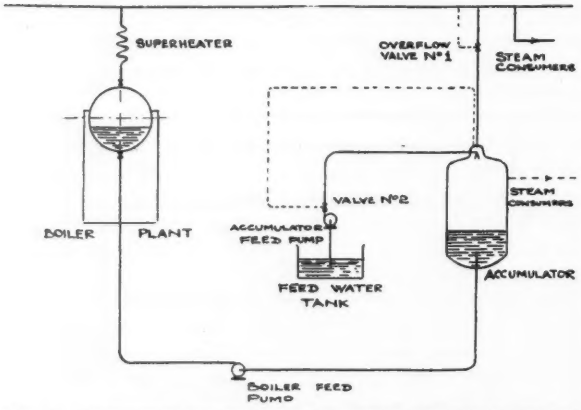


FIG. 2. ANOTHER CONSTANT PRESSURE THERMAL STORAGE SYSTEM KNOWN AS THE DRUITT HALPIN

normally, the feed pump passing the same quantity of water as is being evaporated.

In the first place, the action of the circulating pump will be to set up an increased velocity throughout the boiler, preventing any form of stagnation and in water tube boilers the velocity is such as to sweep all air or steam bells off the heating surfaces, making "water contact" more certain and heat transference more efficient.

If the pressure should now tend to rise, due to a decreased demand, the automatic regulator will "open" admitting more steam to the feed pump and increasing its speed and the quantity delivered; this will naturally tend to raise the water level in the boiler which then cover the mouth of the "over flow" pipe and increase the quantity stored in the accumulator.

The new water passed by the feed pump, will be at a lower temperature than that of the boiler, and the admission of this will tend to lower the pressure. As the demand for steam increases the pressure will tend to fall, with the result that the boiler feed pump is slowed down and may even stop, although naturally the evaporation will continue. Water is now being circulated from the accumulator only, entering the water space at the end and "overflowing" back to the accumulator. If the operation continues, it is obvious that the water level in the accumulator will continue to fall at the exact rate at which it is being evaporated but throughout this period of excessive evaporation, the boiler will be fed with water at boiler temperature and pressure, consequently only the latent heat to convert this water at a given temperature to steam at the same temperature has to be added.

After the peak demand has passed and evaporation becomes normal, the pressure regulator again admits water, restores the water level and endeavors to restore the lost water in the accumulator.

Many advantages of this method of operation are obvious, among the most important of which are:

(a) Constant rate of firing irrespective of the demand for steam.

(b) Combustion conditions maintained constant at the highest efficiency regardless of output.

(c) Constant boiler pressure easily maintained under heaviest possible fluctuations of load.

(d) Possibility of maintaining full output on reduced number of boilers, due to the above conditions—a. b. and c. plus the additional mechanical circulation.

(e) High circulation throughout boiler will tend to prevent deposition of suspended matter and scale forming salts, ensuring clean surfaces and greater head transmission per square foot of heating surface. (The scale and sludge accumulates at the bottom of the accumulator from which it can be drawn as required.)

The accumulator is simply a cylindrical shell or shells, built to withstand the boiler pressure and of sufficient capacity to be able to accommodate the largest and heaviest peak. When more than one tank shell is used, an equilibrium pipe is fitted at front and back at bottom of each tank.

Boiler Feed Pump Is Simply a Booster Pump

From the bottom is taken the suction pipe for the circulation pump; this pipe terminates some 6 in. to 9 in. above the bottom to prevent the heavy sludge and other accumulations being handled when the accumulator is discharged. The entire surface of the tank and pipes is very efficiently lagged and whole protected with a light gage metal casing, usually planished steel.

Another constant pressure system, the Druitt Halpin, as shown in Fig. 2, was invented by an Englishman and consists of a vessel or accumulator containing water placed in series with the feed pump and the boiler feed range. Steam at boiler pressure is admitted to the top of the water through a surplus valve and, upon entering the accumulator, is met by a spray of water from the accumulator feed pump, the quantity of which is regulated by the automatic valve on the outlet of the pump which is operated by the steam pressure in the accumulator. The ordinary boiler feed pump takes its supply from the accumulator and forces this into the steam generator under ordinary conditions.

Operation is as follows: The boiler plant is operated at practically constant load conditions irrespective of the actual draw of steam by the process. When the steam generated exceeds the demand, the surplus valve or overflow valve opens and passes the excess of steam into the accumulator raising the pressure therein, which reacts on the second automatic valve and allows of a large quantity of water being admitted with the sole object of condensing the incoming steam and picking up its heat content. As soon as the boiler pressure falls and there is no surplus steam, the plant operates in the ordinary manner except that the feed pump

injects water at practically the temperature of the steam at the boiler pressure and, by so doing, lowers the level of water in the accumulator. These conditions continue until the pressure again rises and the surplus steam again becomes available and the cycle of operations is gone through again.

This system obviously omits the constant circulation circuit while there is no means of maintaining a constant water level in the boilers as is the case in the Keisselbach plant.

Another difficulty would appear to be that the only possible position for the inclusion of economizers, with the economy due to reducing the flue gas temperature which these bring, is between the accumulator feed pump and the accumulator, and even if you insert them at this point and they function as they should, then the temperature of the water would be such as seriously to reduce the condensing effect at the point of entry of the surplus steam.

In this system, the whole of the feedwater is brought up to the boiler pressure and temperature prior to entering the boiler and it is claimed that most if not all the scale forming salts and sludge, etc., are deposited in the accumulator shell, leaving the heating surfaces of the boiler clean and free from such formations.

In the Keisselbach system, however, the constant and rapid circulation through the boiler ensures that but little or no settlement can take place and these same scale forming salts, etc., are carried out of the boiler proper and deposit themselves in the accumulator where the water is comparatively quiescent as in the former case.

There is no necessity to stress the question of economy—it will be obvious to all who have practical experience in the operation of steam raising plants.

Not only can the general thermal efficiency be raised and maintained but the output of the manufacturing plant should be increased or kept more constant, while frequently it is found that the combustion conditions can be so regulated when relieved of the erratic conditions usually prevailing as to be able to employ a lower grade, consequently a cheaper fuel.

Official Test of Worthington Diesels for the United States Shipping Board

RESULTS OF OFFICIAL tests of the Diesel engines furnished to the United States Shipping Board by the Worthington Pump and Machinery Corp. indicate the tendency in marine Diesel engine practice toward higher piston speeds and, in the case of the two-cycle engines, of the use of independently driven scavenging air blowers. The tests, the results of which are tabulated below, were witnessed and passed by the engineers and inspectors of the Shipping Board. These engines are to be used for marine service but have not yet been installed.

Scavenging Air Supplied by Independent Blower

These engines are of the vertical, four-cylinder, double-acting, two-cycle, air injection type with attached injection air compressor. They were designed to develop 3725 br. hp. and 4700 i.hp. at 115 r.p.m. The principal difference between these engines and the Worthington Diesels now installed on the motor ships M. S. Tampa and the Unicoi is that the scavenging air is supplied by an independent motor-driven blower instead of by an attached reciprocating pump. The speed is also higher, being 115 r.p.m. instead of 95 r.p.m. as in the former vessels and, as a result, the brake horsepower has been raised from 2900 to 3725. The net fuel consumption per br.hp-hr. for the engine alone is about 0.41. Allowing for the fuel used in driving the scavenging blower, the gross consumption is 0.43 lb. per br.hp-hr. In accordance with the United States Shipping Board specifications, these figures are based upon the high heat value of the fuel, 19,000 B.t.u. per lb. Corrected for net heat value, this represents a fuel consumption for engine and blower of 0.402 lb. per br.hp-hr.

The fuel oil used during the tests had an average specific gravity of 19.5 deg. Baumé, a viscosity of 77.3 sec., a Saybolt furol test at 77 deg. F., a high heat value of 18,848 and a low heat value of 17,720 B.t.u. per lb. Heating to approximately 90 deg. F. to make the fuel sufficiently fluid to flow to the fuel pump, was the only fuel treatment permitted. Under these conditions of operation, the exhaust from the engine was practically invisible at all times.

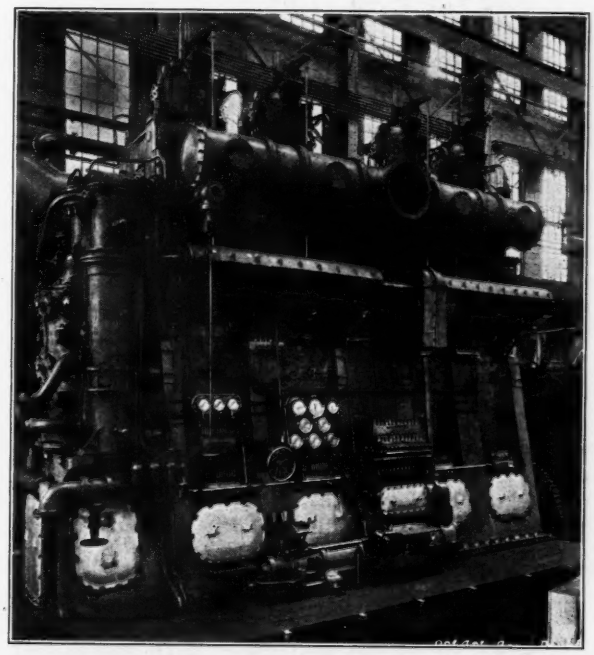


FIG. 1. ENGINE FRONT SHOWING CENTRALIZATION OF CONTROL AND CONVENIENT LOCATION OF GAGE BOARD

As a protection against corrosion, the water passages of the piston rod and both inside and outside portions of the telescopic tubes used for the piston cooling water,

were chromium plated. This plating, incidentally, also protected the tubes against wear at the portions which pass through packing.

Centralization of Control

Simplification of the control gear has been accomplished by moving it forward of the fuel injection pump. One lever now controls the fuel, the injection air and the starting air. A second lever operates the oil and air valves controlling the reversing gear which slides the layshaft and sets the camshaft for the desired rotation. Both levers are interlocked so that it is impossible to set the camshaft for the opposite rotation

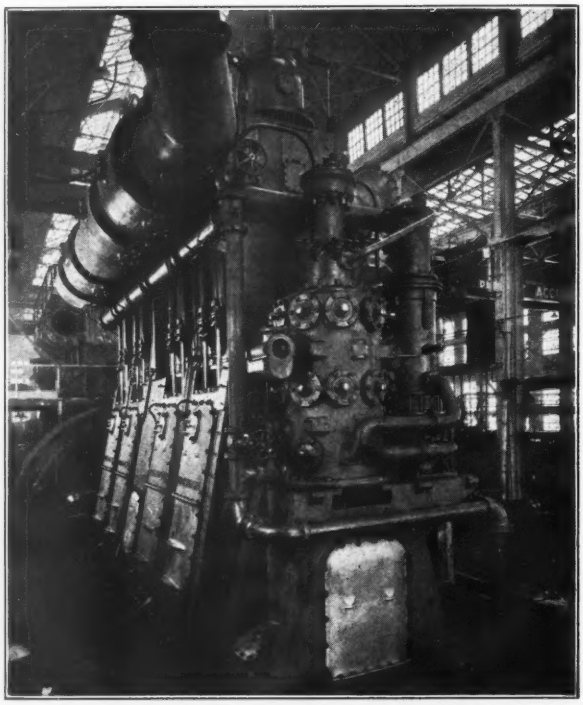


FIG. 2. SIDE AND REAR VIEWS OF ENGINE SHOWING INJECTION AIR COMPRESSOR IN THE FOREGROUND

until the fuel lever is brought back to the stop position. All gages are mounted on the side of the engine at the control station in full view of the operator. The supply of injection air is controlled by throttling the first stage suction. The lever for this purpose is located within easy reach of the man at the controls.

Scavenging Air Blowers Remote Controlled

Remote control switches for the motors of the scavenging air blowers are placed beside the control levers. Two American Brown Boveri turbo blowers directly driven by high speed direct-current variable speed motors are to be installed with each engine. Only one is required for operation, the second serving as a standby unit. Each blower has a maximum capacity of 21,000 cu. ft. of air per minute at a pressure of 2.2 lb. per sq. in. when running at 2800 r.p.m. Under normal conditions, the operating speed is about 2500 r.p.m.

Rigidity, compactibility and convenience of maintenance and control, all so necessary in an engine intended for marine service are embodied in this new Worthington product.

SUMMARY OF SHOP TESTS

Worthington 28 in. diam. by 40 in. stroke—4-cylinder double acting 2-cycle Diesel engine.

Date of Test	Dec. 12-19, 1928	Feb. 18-19, 1929
Duration of test, hours	168	24.
Revolutions per minute	114.96	115.0
B.hp.	3723	3749
I.hp.	4672	4840
M.i.p.	85.9	89.0
M.e.p.	68.5	68.8
Mech. eff. per cent	79.7	77.5
Scavenge blower motor input hp	171	182
Fuel oil (based on 19,000 B.t.u. (high heat value).		
Pounds per i.hp. hour	.327	.322
" " b.hp. hour	.411	.416
" " b.hp. hour (incl. scav. blower)	.43	.437
Pounds per b.hp. hour (inc. blower) (Corrected for net heat value)	.402	.409
Lubricating oil (gal. per 24 hr.)		
Power cylinders	8.73	7.75
Piston rod stuffing boxes	3.08	3.1
Air compressor	.48	1.25
Temperatures (deg. F.)		
Cooling water to engine	59	63
" " from engine	113	112
Exhaust	453	422
Pressures		
Injection air	934	946
Scavenge air	1.77	1.86
Cooling water	38	34
Fuel characterististics		
Gravity Baumé at 60 deg. F	19.5	20
Viscosity (Saybolt Furol at 77 deg. F.)	77	66
Congealing point deg. F	16	13
Water, per cent	0.84	0.83
Sulphur, per cent	0.75	0.76
Distillation above 700 deg. F., per cent	81	92.0
Carbon residue, per cent	5.01	5.98
Heat value (high), B.t.u. per lb	18,848	18,906
Heat value (net), B.t.u.	17,717	17,772

Fuel and Power in Canada, with special reference to the factors affecting American coal are discussed in Trade Information Bulletin 622, recently issued by the Department of Commerce and obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C., price 10 cents. The bulletin discusses Canada fuel and power sources and resources, pointing out that the two important provinces of Ontario and Quebec contain approximately 60 per cent of the population of Canada and 80 per cent of its industrial activity but do not contain any commercially workable coal fields. More than half of Canada's coal requirements, therefore, are supplied by the United States, since about 500 miles directly south of the acute fuel area lie some of the greatest coal fields of the United States, while those of the Maritime Provinces are 1000 mi. to the east and those of British Columbia 2000 mi. or more to the west. Influence of these factors on the coal supply and water power development of Canada are discussed in detail in the bulletin.

To get the best results from compound engines, the load should be almost evenly divided between the high and low-pressure cylinders. This division of load can best be done by means of an indicator raising or lowering the receiver pressure by means of the low-pressure cutoff until the desired result is achieved. A skillful engine operator will be able to determine the proper receiver pressure quite accurately by the feel or vibration of the engine under load.

Tube Failures *in* SURFACE CONDENSERS Increase Maintenance

IN GENERAL, TUBES WITH LESS THAN 70 PER CENT COPPER CORRODE BY DEZINCIFICATION RATHER THAN PITTING. UNDER USUAL CONDITIONS, BRASSES WITH MORE THAN 70 PER CENT COPPER ARE NOT SUBJECT TO DEZINCIFICATION

CONDENSER TUBE failures may take place in a number of different ways which can be listed conveniently as general thinning, dezincification, pitting and splitting.

Thinning of the tube is the result of loss in weight due to corrosion, erosion, or more commonly, a combination of the two. Often erosion, the result of a mechanical scouring by solids carried in the water, accompanies and facilitates corrosion by washing away the products of corrosion to lay bare new metal surfaces.

Such wear is not always evenly distributed either about the circumference or length of the tube. Under certain conditions, impingement of air bubbles at the inlet ends of tubes will cause failure due sometimes to a general thinning of the tube and at others to grooving. Again, tubes which are normally protected from corrosion by a thin layer of scale may be corroded in isolated spots where the scale wears or is chipped off. Depending upon conditions, these spots or corrosion areas may be large or small and often form a characteristic pit with a deep section upstream and a shallow tail downstream.

Splitting or seasonal cracks are due to internal strains or defects in the metal and are usually a result of stresses set up when rolling. Proper annealing or heat treating is effective in reducing this.

Dezincification, which may be defined as the preferential disintegration of zinc in an alloy in the course of which the whole or a part of the copper is left in the metallic state, appears in two forms, the layer or general and the plug type.

The plug type is manifested by the formation on the surface (while completely immersed in the corroding medium) of specks of tightly adhering white substance, which, when removed, shows bright untarnished surface but later a reddish area of spongy copper. Sometimes a green salt of copper distinctly collodial in character, which is mostly an oxychloride of zinc and may contain some carbonate, tinges the white salt. There is no regular distribution of these spots but it appears that a rough surface favors this formation.

COPPER APPEARS TO BE REDEPOSITED

In general or layer dezincification, the tube is not generally thinned down to any appreciable extent but the zinc is taken out and leaving the spongy and more or less brittle copper behind. When broken the tube shows an irregular red or bricklike fracture which, in the case of the tube failure, may extend entirely through the tube wall.

In the layer type, it appears that the change is brought about by a solution of the metal followed by an immediate reprecipitation of the copper and takes place particularly where the circulating water carries free mineral acids or acid forming salts. This may take place in several ways:

First, in the presence of an acid, particularly not too diluted hydrochloric acid and especially when the temperature is high; slightly acid seawater has a similar effect and such waters occur in some bays and along some docks, owing to chemical discharge and decomposition of refuse or to electrolysis when the water contains certain chlorides.

COMPOSITION OF A FEW OF THE MANY MINERALS USED OR SUGGESTED FOR CONDENSER TUBE SERVICE

	Composition in per cent			
	Copper	Zinc		
Ordinary brass	70	30	1	(Tin)
Admiralty metal	70	23		
Muntz metal	60	40		
Tobin bronze	60	39.25	0.75	(Tin)
Leaded bronze*	66.25	33.25	0.5	(Lead)
Phosphor bronze	90	10		
Commercial bronze*	95.5		4	(Tin)
			0.5	(Phos.)
Aluminum bronze*	95		5	(Al.)
Copper nickel*	80		20	(Ni.)
Nickel silver	56.66	28.33	15	(Ni.)

*Exact composition subject to variation as desired

Second, it may occur in the presence of certain neutral or nearly neutral chloride waters when the conditions are favorable for the formation of cupric chloride. This layer type is comparatively free of the copper deposit of white oxychloride of zinc and often there is little deposit of any scale in the copper.

Third, in fresh waters small amounts of acids in the water or slow water speed in the absence of oxidizing conditions may cause this failure. If the content of acid is increased and the amount of air is increased, this condition changes to the thinning of the tubes.

Dezincification by means of an external electromotive force is the result of an accelerated attack on the

metal as a whole whereby the copper is set free from the brass more rapidly than it can be oxidized. This condition may be produced by the deposition of certain salts which, to some degree, shield the copper from oxidization. The resulting copper areas then stand out in relief. This condition becomes more acute the higher the temperature and the higher the zinc content of the tube.

Effects of temperature are shown by the customary higher rate of dezincification and corrosion in the second pass where the water is several degrees warmer than in the first pass. Besides industrial wastes as mentioned above, velocity, acidity and oxygen are other factors, instrumental in corrosion.

Carbon dioxide and sulphur dioxide from the air may be absorbed by the water and tend to lower the alkalinity and increase the corrosion rate but, in general, corrosion is largely maintained by the action of dissolved oxygen with which circulating water is usually saturated.

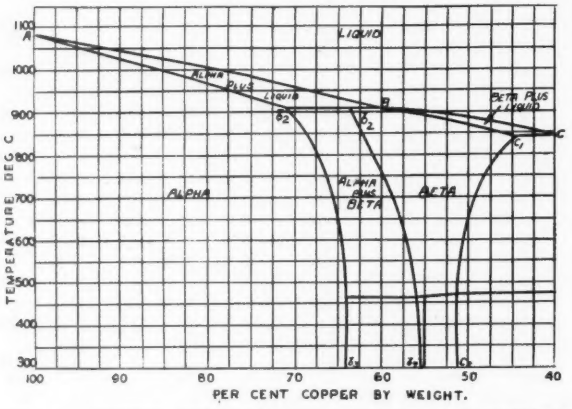


FIG. 1. CURVE SHOWING THE RELATION BETWEEN ALPHA AND BETA BRASS

Action of oxygen on non-ferrous metals is similar to its action on iron. Zinc and brass corrode about 10 times as fast in water with normal oxygen as they do in the same water with most of the oxygen removed. Dezincification is much more rapid in the pressure of oxygen and it appears that in acids the corrosion rate of metals below hydrogen in the electrochemical series is a function of the oxygen available for depolarization.

As a rule, the higher the zinc content of the alloy the more susceptible it is to dezincification. Brass consists of copper and zinc in various proportions, sometimes with small amounts of tin, lead, nickel, arsenic or aluminum. The accompanying table shows the composition of a few of the many metals that are used or have been suggested for condenser tube service.

Beta Crystals More Susceptible to Corrosion

Copper-zinc alloy takes two distinctive forms, alpha and beta, or a combination of both, depending upon the temperature and percentage of copper. Figure 1 (by Chase Co.'s, Inc.) shows the relation between alpha and beta brass. Figure 2 shows the relation of the two at a given temperature. From this, it can be seen that from 100 down to about 63 per cent copper, the alpha crystal forms; below about 56 per cent copper, the beta crystal forms while between 63 and 56 per cent, both alpha and beta occur. The alpha crystal formation is shown by the microphotograph at the top of Fig. 2 and the typical muntz metal structure with both alpha and beta crystals at the bottom.

Microphotographs of a corroded muntz metal tube show a sharp division between the corroded and non-corroded sections. In the normal structure, the small

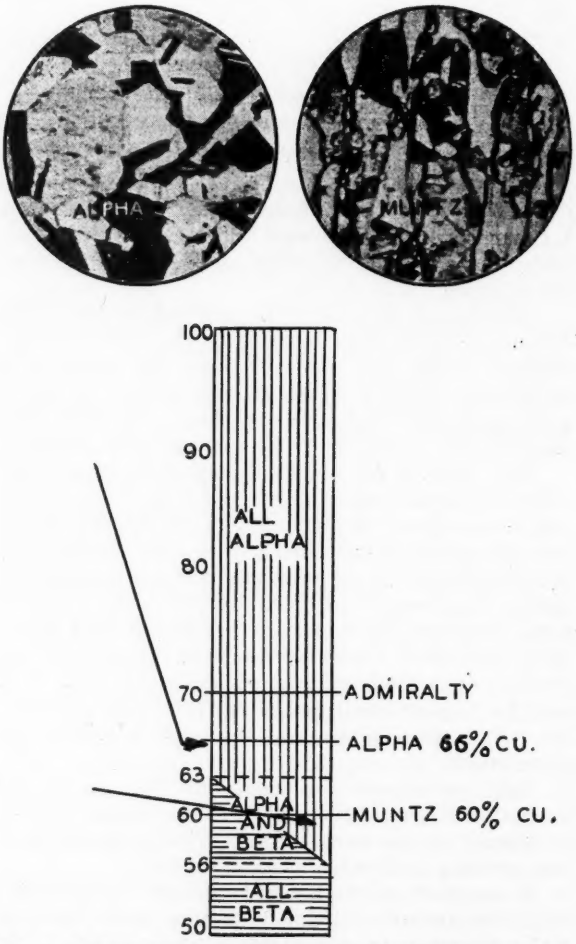


FIG. 2. STRUCTURE OF ALPHA BRASS AND MUNTZ METAL

white clots of alpha brass and the darker material of beta brass between give a considerably brighter effect than in the corroded section where the beta brass is dissolved out, leaving the white alpha crystals standing alone.

It has been demonstrated that with homogeneous layers of alpha crystals at about 0 per cent copper, no local electromotive forces are generated and the resistance against attack is high. Stronger impregnations of eutectic mixture, that is, the addition of beta crystals, cause electromotive forces and the loss of zinc starting at the boundary surfaces of the crystals or at defects in the material.

This electrolytic or so-called galvanic action, which takes place when dissimilar metals are in contact in an electrolyte, may take place in all parts of the condenser because of the different metals or alloys ordinarily used for the tubes, tube sheet and shell. It is popularly supposed that the electric current existing under this

so-called galvanic action causes the corrosion when, as a matter of fact, the current is the result of the corrosion taking place. This does not include external or ground currents which sometimes are the cause of serious corrosion.

Current flow depends upon the position of the respective metals in the electrochemical series. Using zinc as the lowest in the series of metals common in condenser practice, iron, lead, tin, iron and copper are listed in the order named. If two of these metals are connected together, the higher one in the series would be the anode and the lower the cathode. Thus, in combination with zinc, iron would be positive while with copper it would be negative.

In current flow, metal is deposited on the anode at the expense of the cathode. Corrosion of this type has been checked effectively by artificially reversing the current flow or polarity either by impressing an external electromotive force or inserting cast iron or zinc plates in the water boxes so as to make the tubes and tube sheet the positive pole.

Cast iron used for this purpose must be carefully watched, however, as when subjected to corrosion of this kind the graphite content comes into evidence as a surface covering and causes a reversal of polarity which helps instead of hinders the natural tendency toward corrosion. Similar action takes place with particles of coke, carbon and ash which float in with the water and become lodged in the tubes.

Pitting Failures Increase With the Higher Copper Contents

As dezincification becomes less with brasses containing no beta crystals, the obvious solution would be to use brasses with a high copper content. This is done to a certain extent although alloys of this kind have a tendency to pit and lose weight by general corrosion. Figure 3, by H. W. Bassett of the American Brass Co., shows the results of tests made on a number of metals over a period of years effectively shows the tendency of high copper alloys to corrode.

For this reason, admiralty metal, 70 per cent copper, 30 per cent zinc and 1 per cent tin is probably the most widely used condenser tube metal in spite of its susceptibility to dezincification. It may, in fact, be considered the standard condenser tube alloy for seawater and is becoming almost as popular for fresh water service.

For fresh water service, the so-called 70-30 brass (70 per cent copper and 30 per cent zinc) is widely used and where local dezincification is bad, red brass, that is, 85 per cent copper and 15 per cent zinc, has been used to advantage in some cases. In waters containing chlorides, low in calcium salts and temporary hardness, with considerable dissolved carbon dioxide, metal containing zinc should not ordinarily be used.

Special Alloys Developed

A number of companies are using special alloys such as arsenical copper, copper alloys with 20 to 30 per cent nickel, copper-tin and copper-aluminum alloys which are giving good service under extreme conditions. At least one company is using an artificially produced surface layer as a protective skin on the tube.

Of course, condenser tube life does not, except in the case of splitting, depend entirely upon the tube; rather it is a combination of tube composition and treatment, conditions of operation and condenser design. With given conditions of sand, debris, acids, gases or trade wastes in the circulating water, some control over corrosion can be exercised by selecting the tube metal best suited to resist the given conditions. Except in spray pond or cooling tower systems, no control can be exercised over the contents of the water, however, in order to maintain anywhere near constant conditions.

In the design of the condenser itself, much has been and is being done to improve steam distribution so as to avoid hot spots, highly conducive to corrosion, and to correct conditions in the water boxes so as to give more even water distribution and prevent impingement and erosion at the entrance ends of the tubes.

In a given installation with condenser design and circulating water fixed, little can be done except to select and use the tube most suitable for that particular condition. As mentioned above, electrolytic protection is sometimes effective while chemical treatment is sometimes used in plants using closed systems with cooling towers or spray ponds. Sometimes careful screening or improved intake design will help by reducing contributing causes of corrosion. For instance, one company using sea water for cooling water found that wet sand caused rapid corrosion but that in the absence of sand the water was only mildly corrosive. Proper intake design is effective in such cases.

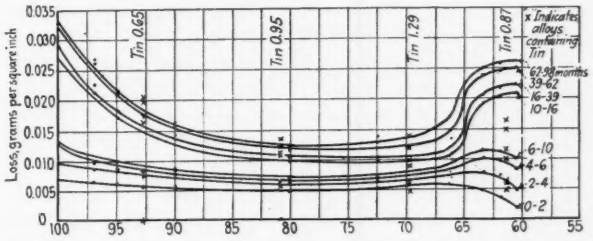


FIG. 3. CORROSION AS SHOWN BY COPPER ALLOYS IN SEA WATER

Power and Heat for Modern Laundry

Attention has been called to some statements in the article under the above title appearing on page 676 of the June 15, 1929 issue which are incorrect, due to changes which have been made or are contemplated.

Although installation of the fan indicated in Fig. 3 will be made as soon as increased load warrants it, this fan has not yet been installed.

Control of both stoker and damper are now accomplished by means of a Brooke Engineering Co. electric combustion regulator and the Ruggles-Klingemann regulators are used to control the steam pressure on the Cochrane hot-water heater when live steam is used in conjunction with the engine exhaust and not for damper regulation as stated.

A cost reducing plan, to be successful, must bring some reward or encouragement to those who carry it out. By using instrument readings and calculated efficiencies, a cash bonus system or competition between shifts can be developed and will work wonders in the average power plant.

Electricity---What It Is and How It Acts*

PART XXVI. THE RELATION OF THE ELECTRON TO ELECTROMAGNETIC RADIATION. MECHANISM OF THE PRODUCTION OF LIGHT. BY A. W. KRAMER.

IN ONE OF THE EARLY articles of this series, a statement was made which implied that electrons are the only things in the universe that exist. In making this statement, the author is conscious of the fact that among the disciples of Schroedinger and Heisenberg it would cause a storm of protest, for these modernists contend that to speak of the electron as a *thing* is just so much rubbish. They contend, and they may be right,

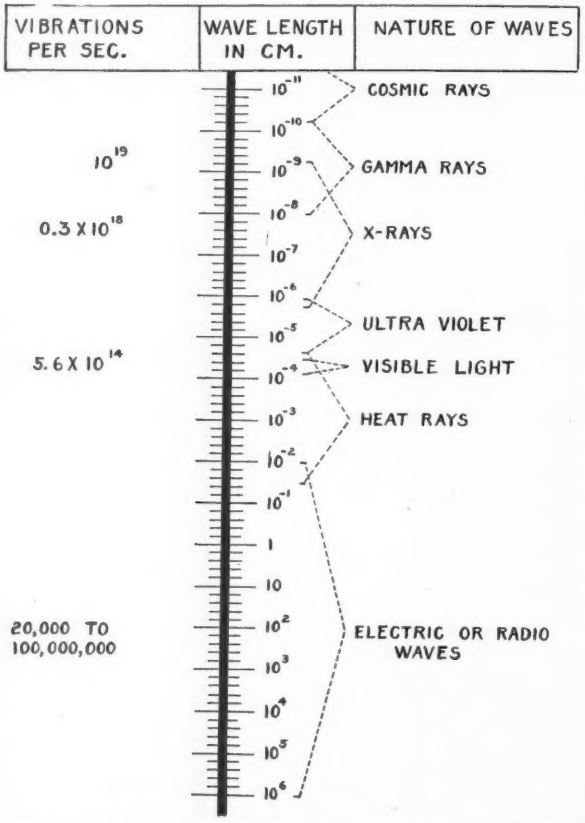


FIG. 1. THE ELECTROMAGNETIC SPECTRUM, SHOWING THE FREQUENCY AND WAVE LENGTH OF THE VARIOUS TYPES OF RAYS. VISIBLE LIGHT, IT WILL BE SEEN, OCCUPIES ONLY A VERY SMALL PORTION OF THE ENTIRE SPECTRUM

that what we speak of as an electron is merely a space-time event; that is only a manifestation of energy.

However interesting these recent theories regarding matter may be, for our present purpose we may disregard them and adopt Professor Eddington's humorous view of picturing an electron as a hard tiny red ball, and the proton as a similar grey one.

Whatever else there may be in the universe, the electron is probably the only thing in it that we can think of as matter and the fundamental laws which govern the mechanism of the electron no doubt are capable of accounting for all physical, chemical and biological phenomena.

For this reason, any detailed discussion of the electron is bound sooner or later to touch upon phenomenon which apparently is not related to the subject under consideration. In this series of articles, we have no intention of describing the relation of the electron to the entire range of physical, chemical and biological phenomena; indeed, that would require a work the size of the Encyclopedia Britannica, but it is necessary to discuss its relation to certain phenomena which are directly concerned with electrical matters.

LIGHT DUE TO THE MOTION OF THE ELECTRON

One of these phenomena is light. There is a very close relation between light and electricity, for light itself is an electromagnetic phenomenon, and its production is the direct result of motions of the electron. Of course, when we speak of light we must think not only of visible light. We must refer rather to a wide range of radiations similar to light in essential nature but differing in the quality variously described as color, frequency or wave length. This range of radiations is known as the electromagnetic spectrum. Visible light occupies only a very small portion in this electromagnetic spectrum and instead of considering the electron as related to the production of only visible light, it will be more to the point here to consider its relation to the production of electromagnetic waves in general.

The electromagnetic spectrum is shown graphically in Fig. 1. As may be seen, the total range of frequencies of radiation is enormous, extending from electric waves of 20,000 cycles per second to the extremely short gamma ray of radium with a frequency of some 10^{19} cycles per second. Expressed in terms of wave length, the range extends from electric waves many miles in length, down through, radio waves, heat waves, light waves, ultra-violet and X-rays to gamma rays one billionth of a centimeter long. The cosmic rays, recently discovered by Millikan coming from interstellar space, are still shorter than the gamma rays and the frequencies are correspondingly higher. These have a wave length of about one thousand billionth of a centimeter.

The enormous breadth of this wave length range may perhaps be better appreciated if we use an illustration recently given by Professor Arthur Compton of the University of Chicago.[1] Suppose we expand the scale until the wave of the cosmic ray has a length equal to the thickness of a post card. On this scale, the longest wireless wave would extend from the earth to the nearest fixed star.

Visible light, it will be noted, occupies only a very small portion of this spectrum, including only those frequencies between 4×10^{14} cycles per second and 7.7×10^{14} cycles per second. Only these frequencies are visible to the eye; all others are invisible and have

*All rights reserved.

[1] In an address before the American Assoc. for the Advancement of Science, December 28, 1928.

to be detected by other means. All of these radiations are of the same nature, however, and except for the heat waves, which are believed to be due to motions of atomic systems, all are created directly by motions of the electron. In the case of radio waves, production is accomplished by the surging back and forth of electrons in wire systems carrying alternating currents. All other radiations except the heat waves already mentioned are due to movements of the electrons within the atom itself.

Radiation of the latter type, visible light, ultra-violet and infra red radiation, X-rays, etc., is due not to the normal motions of electrons in their atomic orbits but to sudden displacements of these electrons from one orbit into another or by the addition of free electrons to ionized atoms. This requires the addition of energy. In the neutral atom, the electrons are in a stable condition and except in the case of radioactive elements are unable to radiate energy.

How Energy Can Be Imparted to Atoms

There are three methods available by which energy may be imparted to atoms: 1. By the addition kinetic energy arising from atomic impact[2] (heat energy). 2. By adding the energy produced by electronic impact. 3. By the addition of energy in the form of electromagnetic radiation.

Let us consider the second method, first. In Part XXI,[3] in discussing the journey of the electron toward the plate of the vacuum tube, it may be recalled, that the kinetic energy of the moving electron was transformed into heat at the plate. The swiftly moving electrons colliding suddenly with the atoms of the plate in some way impart their energy to the latter and this manifests itself as heat. Another point touched upon in the discussion of the vacuum tube was the effect of gas in the tube. If there were gas molecules or atoms in the space between the filament and the plate, they would occasionally be struck by the high speed electrons causing them to be ionized. When this occurred, a bluish glow was noted within the tube. Evidently, in some manner, the electron is capable of producing light.

This blue glow is of considerable interest, because, if it were not produced in the vacuum tube in this manner, we should know very little about the inside structure of the atom. Although accompanying the process of ionization, the production of light is not due directly to the process of ionization but as stated previously, to the process of recombination of the ionized atom with a free electron. To remove an external electron from an atom requires energy; that is, work must be done in moving the electron away from the atom against the attractive force of the nucleus. After ionization, this energy exists as potential energy in the unsatisfied (ionized) atom and is available at any time to draw a free electron into the unsatisfied orbit of the atom. In the case of ionization by impact, the energy required for ionization is supplied by the impinging electron.

Now when a free electron is drawn into the unsatisfied orbit of an ionized atom, something strange happens —we have already mentioned it—a pulse of electromagnetic radiation is emitted. When millions of such pulses are radiated as in the vacuum tube, this radiation makes itself known to our visual sense as light.

We have referred to this light as a *blue* glow. This, however, is not correct for the light produced in this manner is not always blue. It depends upon the kind of gas in the tube. Sometimes, as in the neon lamp, it is red or orange. We used the blue glow as an example merely because that is the color of the light produced in a tube which merely has been partly exhausted of air and in which no other gases have been introduced.

Cause of Variation in Radiation Frequency

Now, what does this mean? It means that with different gases, light of different frequency is emitted from the atoms, for variation in color denotes a variation in the frequency of radiation.

Upon first thought, this may appear rather strange. Why should the frequency of the emitted radiation depend upon the nature of the gas? Certainly, the process of ionization and recombination are the same regardless of what gas is used.

Let us investigate this a little more closely, however; let us measure the amount of energy required to ionize atoms of different kinds, or what amounts to the same thing, let us determine the ionization potential for each gas. At once, we find a clue, for as already mentioned,[4] the ionization potentials vary for atoms of different elements. For helium it is 25 v., for oxygen 15.5 v., for neon about 20 v.

This variation in the ionization potential for different elements means that the velocity of the impinging electron (consequently its energy content) will be different for each different atom. It will be higher for helium than for oxygen.

Here, then, we have an explanation of the different colored radiation from various gases. The frequency of the emitted radiation is proportional to the energy required to ionize the atom. This law is of great importance in the study of the atom, for it gives us an insight into the way in which energy is absorbed or emitted by atomic systems.

Relation of Frequency to Energy

It now becomes necessary to introduce a mysterious letter, which, so far in this series, we have been able to avoid. Sooner or later, however, in any discussion of the atom, we are bound to meet it, so this is as good a place as any to bring it to light. This is the unassuming lower case letter h. Ordinarily we do not think the letter h mysterious or anything to get excited about, but when it denotes Planck's constant as it does here, it becomes one of the most mysterious things in the universe. We shall hear much more about Planck's constant later but here we introduce it because it appears in a simple equation which expresses the relation between the energy required to ionize an atom in the first instance and the frequency of the light emitted when an electron returns and neutralizes the ionized atom. Denoting by E the energy which an electron must acquire before it removes an electron from an atom, and by v the frequency of the light emitted on the return of an electron to the atom, we have the relation

$$E = h\,v$$

where h denotes Planck's constant.

[2]Part V, July 15, 1928 issue, p. 778.
[3]April 1, 1929 issue, page 417.
[4]Part XXV, June 1, 1929 issue, page 642.

In investigating the relation between the ionizing potential and frequency of radiation, different observers found different values of ionizing potential for the same kinds of atoms. This was puzzling at first but it turned out that in some cases the effect of the collision was not to remove an electron entirely away from the atom, but merely to lift it into another orbit around the nucleus, in which it was momentarily stable and where it remained for an instant before falling back into its original orbit. In thus returning to its original orbit, it emitted a pulse of radiation, the frequency of which was proportional to $\frac{E}{h}$ as given by the foregoing equation. This pulse of radiation represents the energy due to the falling in of the electron.

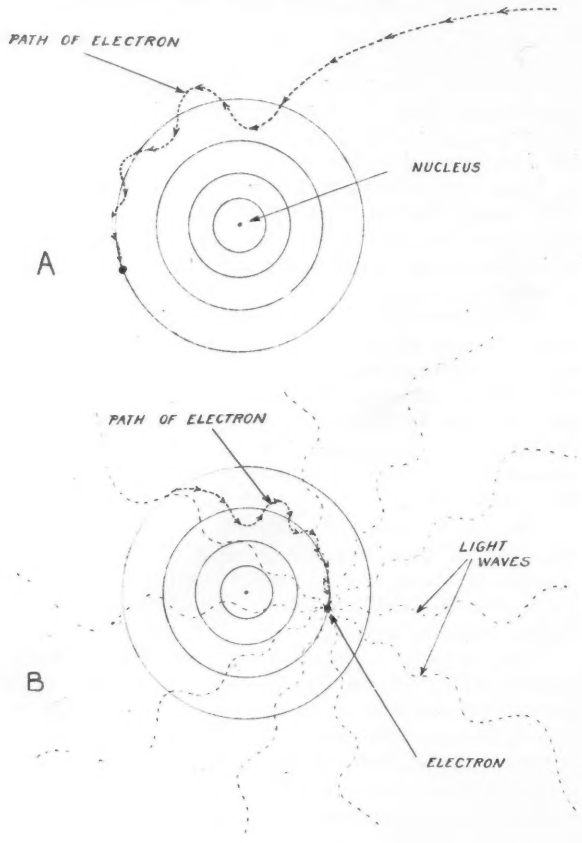


FIG. 2. WHEN AN ELECTRON FALLS BACK INTO AN INNER ORBIT OF THE ATOM, LIGHT IS PRODUCED

This diagram attempts to show the manner in which light is produced. At A a free electron is drawn into the outer orbit of an atom. At B, an electron in an outer orbit falls into the next lower one. In both cases light is produced. In the lower diagram an attempt has been made to show the light waves resulting from the fall of the electron. The action of an electron in falling to a lower orbit may be compared with that of a pendulum. (See text.) For the sake of clearness the light waves have been omitted from the upper diagram.

Excitation Potentials

In this latter case, no ionization occurs, for the electron does not leave the atom but is merely displaced for an instant. The potentials necessary to cause such displacements of electrons are called excitation potentials. Thus a high speed electron colliding with a neutral atom may do either of two things depending upon its energy or what amounts to the same thing, its velocity at the moment of impact; it may knock an external electron clear out of the atom or it may merely jump the electron struck into another orbit further away from the nucleus.

In this new position, the displaced electron is temporarily stable and remains there for perhaps 1/1000 or 1/10,000 of a second or even less. The atom, during the time that an electron is so displaced, is in what Professor Bohr calls a stationary state. When the electron falls back to its original orbit, it emits a definite unit of radiation, the wave length or frequency of which is defined by quantum[5] relationships.

This, then, is the manner in which light is produced; by the falling in of electrons, which have been displaced away from the nucleus, due to the addition of energy from an outside source.

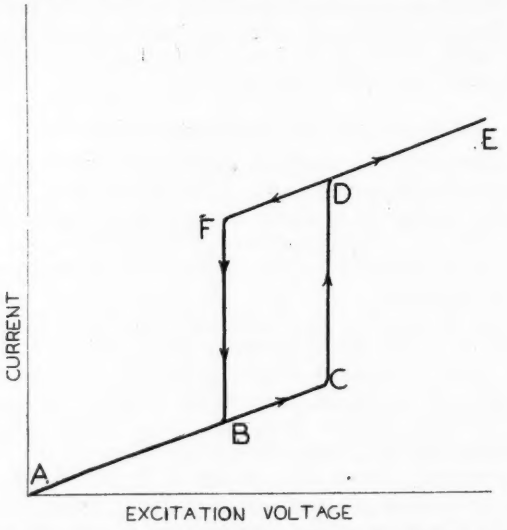


FIG. 3. CURVE SHOWING THE RELATION OF PLATE VOLTAGE TO CURRENT UNDER THE EFFECT OF CUMULATIVE IONIZATION

In Fig. 2 an attempt has been made to show how a pulse of radiation might be produced. Two cases are shown; in one, free electron falls into the outer orbit of the atom while at B displaced electron temporarily in the outer falls back into its original orbit. Like any other accelerated body, an electron falling to an inner orbit acquires kinetic energy. At the moment the electron reaches its original orbit, this kinetic energy is a maximum. Instead of stopping at its proper orbit (where it is stable) it passes beyond, proceeding further into the atom. Immediately, however, it is acted upon by the restraining forces of the atom as a whole, which tend to check its motion toward the center and finally reverse its movement. Again, as the electron approaches its proper orbit, it builds up a store of kinetic energy so that when it reaches the orbit it once more passes over. The action is exactly like that of a pendulum. When a pendulum is at its highest point it possesses potential energy by virtue of gravitational attraction. As it swings downward, this potential energy is transformed into kinetic energy. Thus the pendulum passes beyond its lowest point and proceeds upward on

[5]The quantum is a unit of energy, variable in amount and directly proportional to the frequency of the radiation emitted by an electronic oscillator.

the opposite side of its swing until the force of gravity brings it to rest. With each swing, however, some of its energy is dissipated as heat so that finally the pendulum comes to rest.

In the same way, the electron oscilllating about its proper orbit is finally brought to rest. In this case, however, the energy is dissipated, not as heat, but as light. As soon as the electron stops oscillating about its orbit, it ceases to radiate.

It will be obvious from this that the frequency of oscillation is dependent upon the energy of the electron and this in turn is governed by the distance of the orbit involved from the nucleus of the atom. The closer to the nucleus, the tighter will the electron be held to the nucleus and when displaced, the more rapid will be the oscillations it undergoes in finding stabilization. The action is identical with that obtained when a violin string is plucked. If the string is stretched tightly, the vibrations will be rapid; if stretched loosely, the rate of vibrations will be slow.

That fact that a displaced electron is in a temporarily stable state for an instant is responsible for an interesting effect. It is evident that when an electron is moved from an inner to an outer orbit, the amount of energy required to remove it entirely from the atom will be less than when it was in its original orbit. Suppose then that during the moment the displaced electron remained in this new orbit, it was struck by another electron. It is evident that in this case the electron might be entirely removed from the atom—that is the atom would be ionized.

Such a condition can easily be brought about, by subjecting a gas to an intense bombardment by electrons emitted from a hot filament. An instant after this bombardment starts, it is obvious that a large number of atoms of gas will have electrons in the stationary state. Many of these will be hit by other bombarding electrons before they can fall back into their original orbits. In this case, it will be seen that the whole conditions for ionization are altered, as part of the work necessary for complete ionization was done when the electrons were shifted into fresh orbits. In this way, it is possible to secure ionization with less than the ionization voltage of the atom involved.

Under such conditions, if currents are plotted against potential an interesting curve is obtained as shown in Fig. 3. In this case, the current at first increased steadily from A to C, but upon reaching C it pumped suddenly to D. In some instances, this jump implies a tenfold increase in current. With a further increase of potential, however, the current again increased steadily as indicated along D E. Upon reversing the process and diminishing the voltage, the original path was not retraced but the current continued along the upper curve to F when it fell suddenly to B. Thus it is possible to get two different currents with the same voltage, a circumstance due to the cumulative ionization described.

Protection of Transmission Lines by Relays*

PART III. PRINCIPLES OF OPERATION AND APPLICATION OF REVERSE POWER RELAYS. BY E. H. STIVENDER.†

REVERSE POWER RELAYS are employed at the receiving ends of parallel feeders in preference to current differential relays, for reasons already explained. The Westinghouse Co. manufactures instruments of this type in two classes; namely, duo-directional relays and uni-directional relays. The former differ from the latter in possessing selective contacts, which close when power flows in either direction. They are especially desirable for the protection of two parallel feeders, since their use eliminates one set of relays. For protection of more than two feeders, uni-directional relays are used since, in that case, it is necessary for the contacts to close only with a reversal of current. This type of relay may be employed at either end of parallel transmission lines but, as their expense is greater than that of current differential instruments, also because they require potential transformers, they are mainly used only at the distribution end and where balance protection at the generating end of four or more parallel feeders is required.

Reverse power relays of this company have an independent overload element contained in the same case with the directional element, which is exactly the same as their inverse time limit overload relays.

Figure 11 is an elementary diagram illustrating the internal connections of the duo-directional relay. The overload element consists of a torque compensator and relay element. The torque compensator furnishes the inverse time characteristics, its circuit containing the coils X, Y and Z, with coil O in the current transformer circuit. The directional element closely resembles the element of a single-phase watt-hour meter and its operations are precisely the same. It is composed of two current coils M, connected in series, and a potential coil N. When the coils are energized they produce a rotating field flux in the core, which acts upon the disc carrying the movable contacts of the trip circuit. Operating current settings for this instrument are accomplished by changing taps on coil O of the overload element. Springs serve the double purpose of holding the contacts in open position and of acting as conductors for the trip current to the movable contacts.

Even in systems with a relatively high power factor load, short circuit current will sometimes be of low power factor. A single-phase watt-hour meter will reverse if the angle of lag becomes greater than 90 deg. and, to prevent reverse power relays from becoming inoperative or operating falsely on serious short circuits, they are designed to operate normally with the current leading the voltage by 30 deg. when the system power factor is 100 per cent, this phase angle being produced in practice by the connections of the potential circuit.

Figure 12 is a diagram of duo-directional relays connected for differential operation at the receiving ends of two three-phase parallel feeders. Since the overload and directional contacts are in series the over-

*This is the final installment of this article. Part I appeared in the July 1 issue and Part II in the July 15 issue.

†Engineer, Dixie Construction Co.

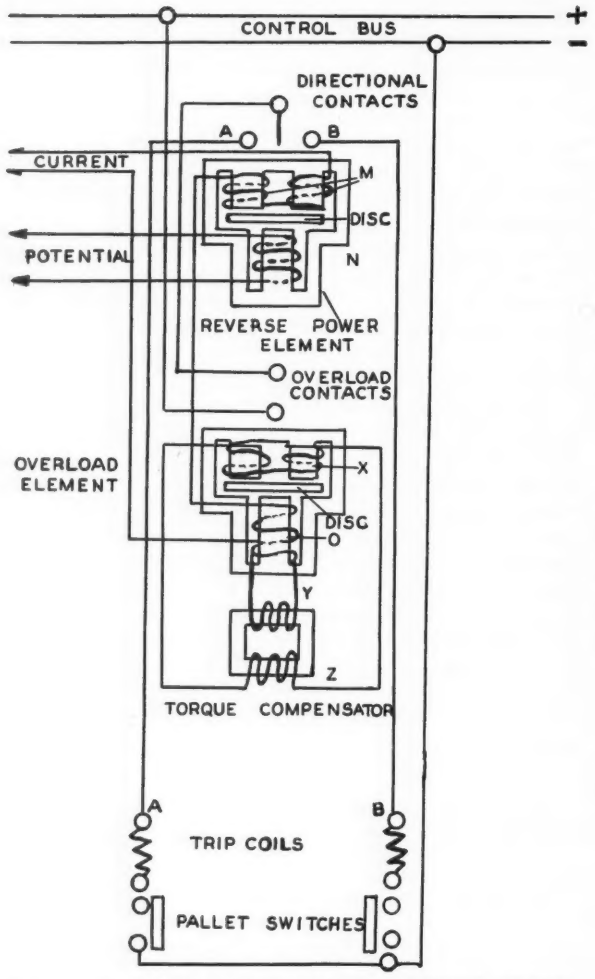


FIG. 11. DIAGRAM OF INTERNAL CONNECTIONS OF DUO-DIRECTIONAL REVERSE POWER RELAY

load contacts are not illustrated. A typical example of a high-voltage substation is one in which a star-delta-connected power transformer bank feeds the low-tension bus and, for economy, instrument potential transformers are operated from the secondary side of this transformer bank. Figure 12 shows the connections for such a system; the potential transformers are connected in open-delta and the relays in star, which makes the period of the current 30 deg. ahead of the voltage in each relay. Since this connection causes a reduced voltage across the potential coils, special low voltage relays must be provided. The current transformer circuit is the same as for current differential relays and, under normal conditions, the relay current coils will not be energized. The contacts are so connected that when current reverses in either feeder the circuit breaker of that feeder will be tripped out. Pallet switches are in the current transformer circuit so that when either circuit opens, its current transformers will be shorted out, in which case the current transformers of the active feeder must continually supply current to the relays but in the correct direction, so that the contacts of the open breaker trip circuit are closed. Thus the remaining feeder is afforded reverse current protection.

In Fig. 13 is a connection in which two parallel feeders are protected at the receiving ends by uni-directional relays. In this case there are two relays per phase, the current coils of each phase being connected in series. One set of relays closes the trip circuit of one circuit breaker while a corresponding set closes the trip circuit of the other. The potential coil connections are opposite with regard to the two groups, in order that the two sets of relays will operate under relative reverse current conditions. The 30-deg. angle of lead is produced by connecting the relay potential coils in delta, since the feeders are in synchronism with the potential transformer primary in this connection. As in the case of duo-directional relays, one feeder has reverse current overload protection after the other has been tripped out.

Reverse Power Relays on Four Parallel Feeders

Figure 14 shows the usual connections for cross-connected reverse power relays when applied to the protection of four parallel feeders. To simplify the illustration, only No. 2 phase is shown. All current transformers are connected in series, with a relay current coil across each current transformer. Under normal conditions, secondary current will circulate through the transformers, none passing through the relays since the forces across their coils are equal and opposite. Should a fault occur on one line, current will flow through its relays in a direction to close its contacts, while current will also flow through the other relays but in the opposite direction, so that only the circuit

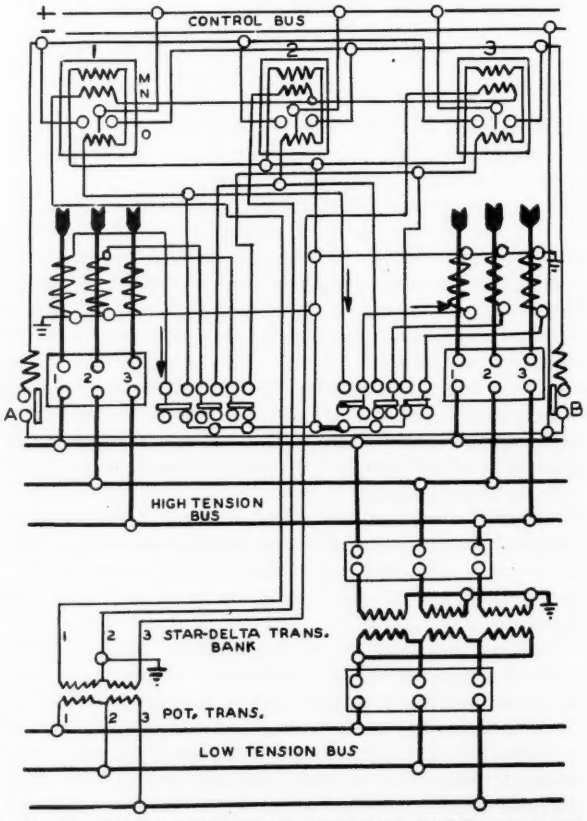


FIG. 12. DUO-DIRECTIONAL REVERSE POWER RELAYS CONNECTED FOR DIFFERENTIAL OPERATION AT RECEIVING ENDS OF TWO THREE-PHASE PARALLEL FEEDERS

breaker of the defective line will be opened. Pallet switches automatically short out each set of current transformers as its circuit breaker is opened; this action restores the balance across the remaining protecting relays. This connection affords protection until only one feeder remains energized and in this case there is no relay protection, since all the other current transformers will be short circuited, thereby short circuiting the remaining one. This necessitates the use of separate overload relays.

Advantages and Disadvantages of Reverse Power Relays

The chief advantages of cross-connected reverse-power relays are, as in all cross-connected current differential relay schemes, that they are inoperative with all loads regardless of their magnitude, until the load in the protected feeders becomes unbalanced, a feature which makes immediate changes in cross-connected relay settings unnecessary with a change in normal full load of the lines, and they can be set at time and current values independent of all other relays on the system.

Although possessing advantages over current differential relays when used at the receiving end and for four feeders at the generating end, certain extra precautions must be taken when a new feeder is being put into service and the relay is set for light load, as is usually the case. If the breaker at the receiving end is closed first, the new feeder will be immediately tripped out, for the current transformers of the active feeders will then feed in a reverse direction through the relays of this feeder. When reverse power relays are used at the generating end and a new feeder is cut in, reverse current will flow in the relays of the active feeders, tripping them out. The usual precaution is to open the control circuit of the relays at the receiving end of the new feeder, while the circuit breaker at that end is closed first.

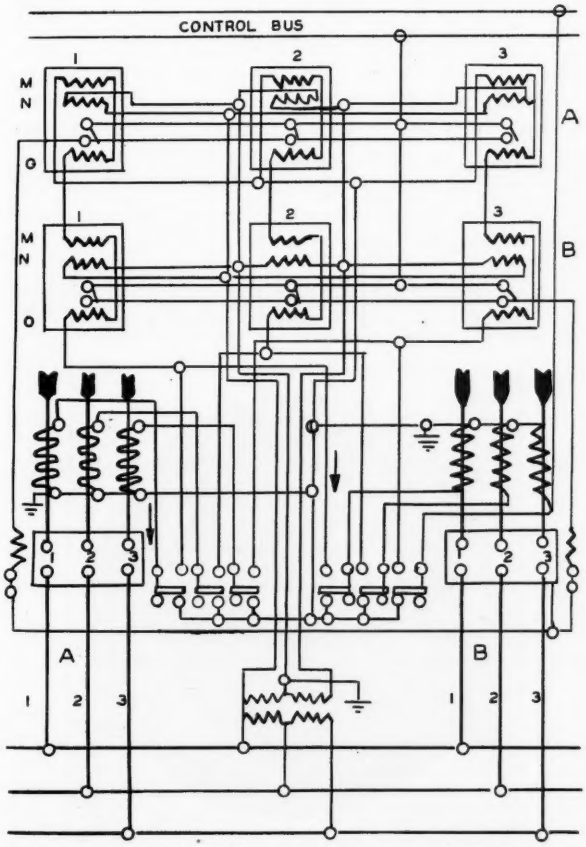


FIG. 13. TWO PARALLEL FEEDERS PROTECTED AT RECEIVING ENDS BY UNI-DIRECTIONAL REVERSE POWER RELAYS

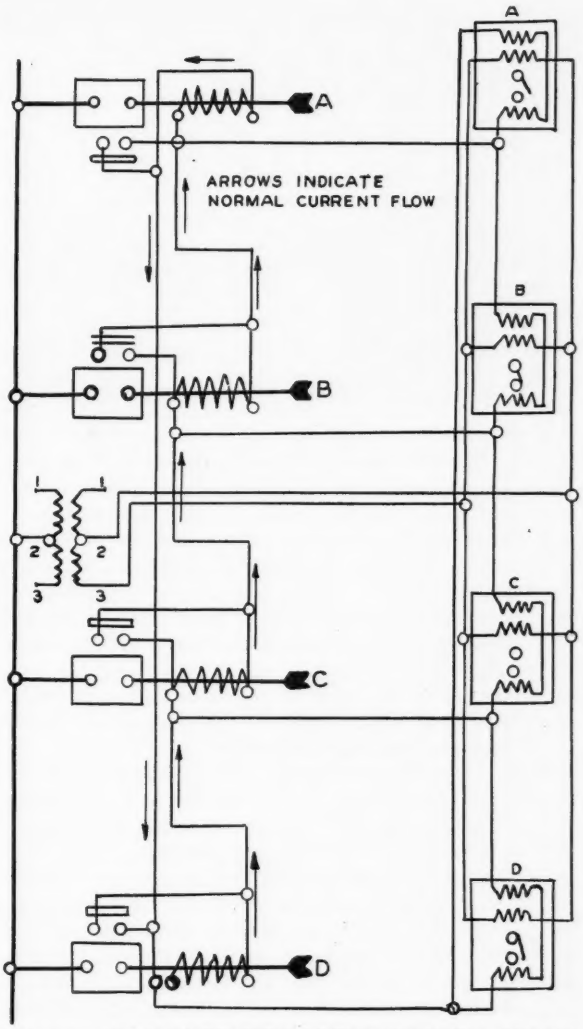


FIG. 14. CROSS-CONNECTED REVERSE POWER RELAYS FOR PROTECTING FOUR PARALLEL FEEDERS

Another disadvantage of reverse power relays is that, when they are used on more than two parallel feeders, all current transformers cannot be grounded, which sacrifices safety to a certain degree. The trip circuits of all circuit breakers should be opened by auxiliary pallet switches to relieve the relay contacts of destructive arcing.

One of the fundamental laws of hydraulics states that the downward pressure of a liquid is proportional to the depth and density of the liquid. This downward pressure is independent of the shape of the vessel. The sidewise pressure of the liquid varies in the same manner as the downward pressure and at the same depth the two are equal.

HYDROGEN *Cools Large* SYNCHRONOUS CONDENSERS

Hydrogen is an excellent cooling medium for high-speed rotating electrical machinery and has many advantages over air. Higher loads can be carried and the life of the machines increased. Two synchronous condensers using hydrogen gas for cooling were installed in 1928.

AMONG THE VARIOUS papers presented at the recent summer convention of the American Institute of Electrical Engineers at Swampscott, Mass., one which created considerable interest was a paper on Outdoor Hydrogen Ventilated Synchronous Condensers by Robert Wieseman. The use of hydrogen as a cooling medium for rotating electrical machinery is a recent development. So far, it has been used only in outdoor synchronous condensers but there seems to be no logical reason why it cannot be used successfully in other rotating machinery.

Hydrogen is an excellent cooling medium for high-speed electrical machinery. When it is substituted for air, a machine can be operated at a higher load with the same temperature rise and the windage load is decreased to one-eleventh. The density of hydrogen is only 7 per cent that of air, consequently the windage loss of a rotor running in an atmosphere of pure hydrogen is only 7 per cent that of the air loss. Hydrogen also conducts heat about seven times better than air and the specific heat of a gram of hydrogen is about 14.5 times that of a gram of air. Heat, therefore, passes across the small spaces in the insulation and between the laminations, etc., much more readily than with air cooling; thus the internal copper temperatures for a given surface temperature is less in hydrogen than in air.

In an atmosphere of hydrogen, 30 per cent more heat can be transferred from heater surfaces than in air with the same surface temperature drop. Furthermore, when the hydrogen comes in contact with the surface cooler, more heat can be transferred to the cooler than with air. This again enables a smaller surface cooler to be used; or, with the same cooler, a lower cooling medium temperature is realized. The reduction of windage loss, the increased thermal conductivity and forced heat convection of hydrogen result in an increased output of 30 per cent or more, depending upon the hydrogen pressure used, the type of ventilation employed, the degree of saturation in the magnetic structure and the stability required.

Since no oxidation can take place with this type of machine, the life of the insulation is increased and short circuits and corona troubles are materially reduced. Proofs have demonstrated that the damage caused by corona is practically absent in an atmosphere of hydrogen. Machines using this type of ventilation are quiet and can be placed out of doors without increase in vent.

Disadvantages in Ventilating with Hydrogen

When hydrogen cooling was first proposed, some difficulty in preventing accidental explosion was anticipated. The increasing familiarity with the problem and the extensive use of hydrogen for many industrial processes indicate that there should be no difficulty with this problem.

A mixture of hydrogen and air will not explode if the hydrogen content by volume is more than 70 per

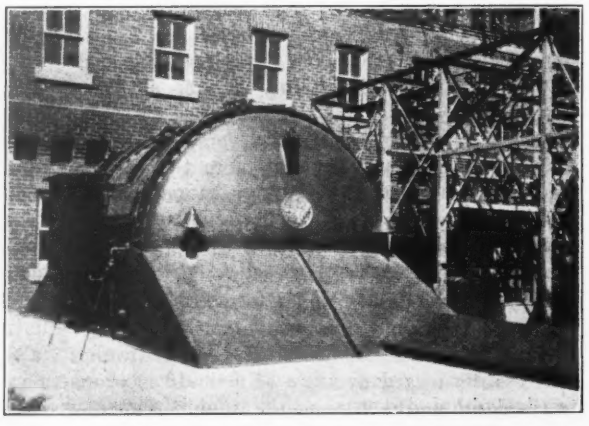


FIG. 1. THE FIRST OUTDOOR HYDROGEN VENTILATED SYNCHRONOUS CONDENSER

12,500-kv-a., 900-r.p.m. 3-phase, 60-cycle, 13,800-v. installed at the Pawtucket, R. I., substation of the New England Power Co.

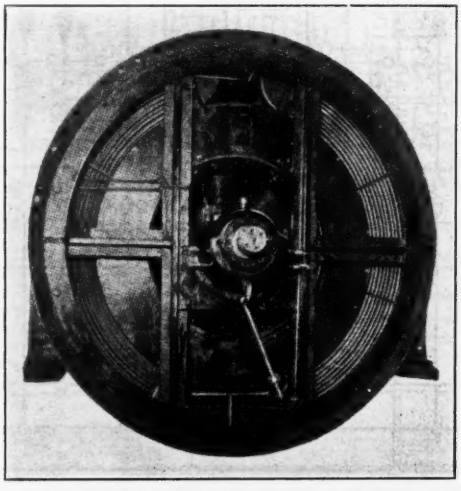


FIG. 2. 12,500-KV-A. HYDROGEN VENTILATED SYNCHRONOUS CONDENSER WITH END HEAD REMOVED

cent or less than 10 per cent. In hydrogen-cooled electrical equipment, the hydrogen pressure in the machine is automatically maintained slightly above atmospheric pressure. This prevents air from leaking into the machine and eventually the hydrogen purity will reach that of commercial hydrogen which is usually around 99 per cent. Even with a combustible mixture of hydrogen and air, however, the amount of energy stored in an ordinary electrical machine is comparatively small. The following table gives the stored energy in a steam boiler, in a large turbine generator rotor, and in the gas of a hydrogen ventilated synchronous condenser when it contains the most explosive mixture of air and hydrogen.

	Stored energy foot-pounds	Per cent
Steam boiler 2000 boiler hp	$25{,}000 \times 10^6$	100
Large turbine-generator rotor	300×10^6	6.0
Hydrogen-ventilated machine containing 1000 cu. ft. of the most explosive mixture of air and hydrogen at atmospheric pressure	70×10^6	1.4

Another disadvantage of a hydrogen-cooled machine that has been cited is the increased disassembly expense. If a hydrogen ventilated condenser must be disassembled for repairs, more time will be consumed and more expense will be involved than with a standard air-cooled machine. On the other hand, it should not be necessary to dismantle the hydrogen ventilated machine so often because of its longer insulation life, its lower bearing and internal coil temperature and the absence of dirt.

Description of Outdoor Installations

Several installations with this method of cooling have already been made. The first commercial application of hydrogen cooling for electrical machines was made on a 12,500-kv-a. outdoor synchronous condenser. This machine is installed at the Pawtucket, R. I., substation of the New England Power Co. Another outdoor hydrogen-cooled condenser designed along these lines, rated at 20,000 kv-a., is also in operation. This machine is located near Charleston, West Virginia, at the Turner substation of the Appalachian Electric Power Co. As both of these machines are installed outdoors, both are placed over a pit which is made weatherproof by substantial sheet iron covering. In this pit are located the cooling water circulating pumps, air pumps for cooling the bearings and furnishing high pressure oil for starting, the hydrogen supply tanks, the hydrogen pressure gage, indicating thermometers, the automatic hydrogen pressure control, the rotor hand pressure gage for indicating the hydrogen purity when the machine is in operation, the thermal cell of the hydrogen purity indicator which indicates the hydrogen purity at all times and the various cells for controlling the water, oil and hydrogen.

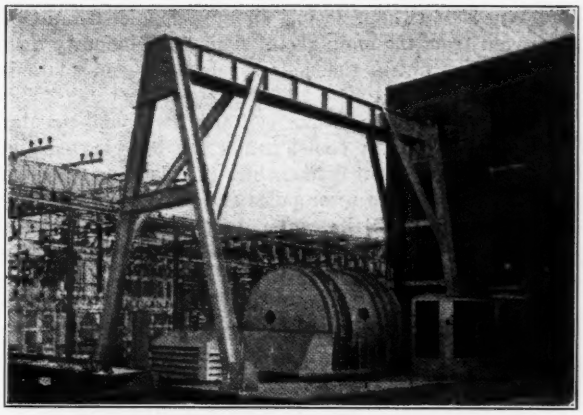


FIG. 4. THE 20,000-KV-A., 800-R.P.M., 3-PHASE, 60-CYCLE, 11,500-V. OUTDOOR HYDROGEN VENTILATED CONDENSER AT THE APPALACHIAN ELECTRIC POWER CO., CHARLESTON, W. V.

In order to minimize the effect of an explosion resulting from careless operation, these condensers were provided with a cylindrical explosion-proof frame designed to resist the disruptive force of the most explosive mixture of hydrogen and air at atmospheric pressure. The frame of the 12,500-kv-a. condenser without winding, coolers and piping was filled with the most explosive mixture of hydrogen and air and the gas was ignited with a spark plug. No damage resulted from the explosion, which developed a maximum pressure of 85 lb. per sq. in., as recorded by an instantaneous pressure recorder. If the machine had been completely assembled with all the various metallic parts, especially the coolers, the pressure would have been only about 60 lb. per sq. in.

Because the shaft of a synchronous condenser does not extend beyond the casing, no shaft seal is absolutely necessary; however, it was thought advisable to place a seal around the cap where it entered the collector housing in order that the collector brushes might be adjusted

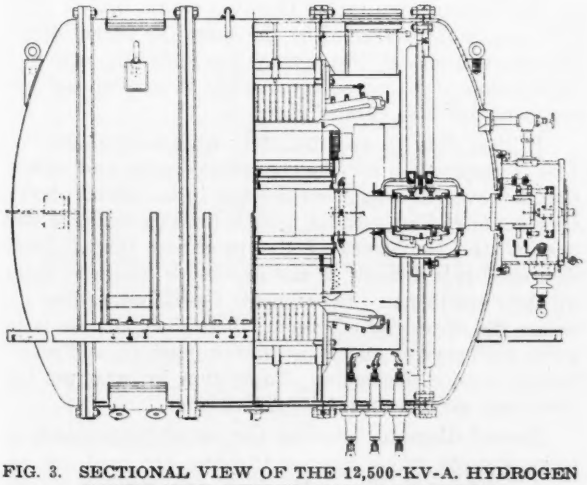


FIG. 3. SECTIONAL VIEW OF THE 12,500-KV-A. HYDROGEN VENTILATED SYNCHRONOUS CONDENSER

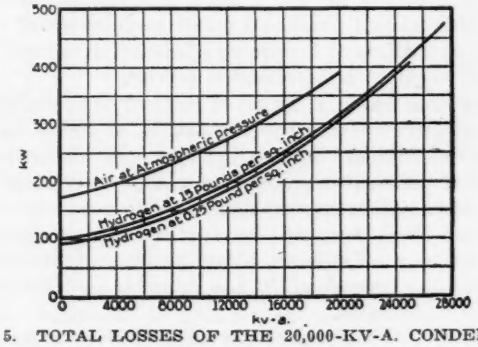


FIG. 5. TOTAL LOSSES OF THE 20,000-KV-A. CONDENSER

and renewed without losing an appreciable amount of hydrogen from the main shell. This seal obviously does not function unless the collector housing end plate is removed.

Each end of the frame contains two semi-circular surface coolers. The cooler heads can be removed and tubes cleaned without dismantling the machine or losing any hydrogen. The rotor poles and fans force the ventilating gas through the center ducts to the bank of the center frame. Then the gas passes through the semi-circular coolers and is returned to the rotors and recirculated. With the pressure of the hydrogen about ½ lb. per sq. in. above that of the atmosphere, the gas leakage is extremely small and does not cost more than 15 to 20 cents a day.

The excellent cooling properties of hydrogen enable a given machine to operate at an increased output at the same temperature rise. The following table shows how the output of high-speed condensers increases with the same temperature rise when hydrogen is used for the cooling medium.

Cooling medium	Machine output
Air at atmospheric pressure	100 per cent
Hydrogen at a pressure slightly above atmospheric pressure	125 per cent
Hydrogen at a pressure of 15 lb. per sq. in. above atmospheric pressure	140 per cent

The results obtained on these two hydrogen ventilated synchronous condensers to date have been very encouraging and three more machines rated at 15,000 kv-a. are under construction. Not only have the hydrogen features of the machine performed satisfactorily but during the past winter the machines have operated successfully out of doors, with no protection from the weather. Thus, outdoor synchronous condensers, whether air or hydrogen-cooled, should give reliable service at a reduced overhead expense.

Electrical manufacturers are constantly striving to improve the efficiency in the ventilation of rotating machinery. High-grade magnetic steel, transposed armature winding, correct magnetic densities and precautions, improved rotor fans and ventilating ducts, center and more compact insulation, etc., all tend to reduce the losses and the size of the machine. These refinements, however, have been worked over so exhaustively that further improvements in performance characteristics by these means will perhaps be relatively small. Any appreciable gain must come by the way of a radical change in machine structure, materials or ventilating medium. Hydrogen cooling is one of these radical departures from tradition which open up new avenues of progress and rotating machines with 99 per cent efficiency may soon be a reality.

Instruments Widely Used on Bleeder Turbines

Operators Know at All Times the Exact Conditions of All Parts of the System from Readings of Well-Kept Instruments

INSTRUMENTS OF ALL KINDS are so widely used in modern power plants that justification for their installation, from a financial standpoint, is no longer contested; however, in the smaller plants, especially industrial installations, this condition is often reversed and any instruments beyond the pressure gage, demanded by law for the boiler, is considered an extravagance.

Obviously, in order to operate the power plant at its most efficient point, it is necessary for the operating men to know accurately the condition existing at every point of the system. This is especially true of industrial installations where the power plant is tied in with process work.

In a central station engaged in making and selling electric power, all power equipment is what would be known as a productive department in an industrial plant, that is directly engaged in producing a salable product. Practically every piece of equipment installed is considered and purchased on its usefulness and value either as a means of increasing efficiency or as insurance against accident or interrupted service.

For this reason, a study of instrument installations of representative central stations is of value to the industrial engineer because it shows him where instruments of different types can be used to advantage. In some cases, indicating readings used to guide the operator and check results at any given times are satisfactory while, in other cases, recording instruments, giving a permanent record which can later be used for reference, are desirable.

[1]See Power Plant Engineering page 613, June 1, 1928.

In many plants, it is becoming the custom to set up a hypothetical curve of performance showing what would be accomplished if each unit or piece of equipment were operated at the most desirable efficiency. Other plants content themselves with making daily, weekly or monthly calculations of overall results and comparing them with each other to show the trend of operation.

Intelligent Use of Instruments Is Necessary

Intelligent use always justifies expenditures for instruments but, as a general rule, it is better to install too few instruments rather than too many, that is more than can be taken care of by the operating organization. In large stations, all instruments are under the care and supervision of a trained crew, while in smaller stations one man can take care of them.

If this duty is not definitely assigned to someone who is responsible for their continued care and operation, however, as is so often the case in industrial plants, they get out of adjustment, give erroneous readings and destroy the confidence of the operating force. Once destroyed it is difficult, if not impossible, again to build up their confidence. Instruments themselves cannot increase the operating efficiency; their sole purpose is to guide the operator and assist him in reaching and maintaining higher efficiencies. To do this, he must use the data they give in an intelligent manner.

Several diagrams showing the use of instruments in large stations where bleeder turbines are used are reproduced from the Prime Movers report of the N.E.L.A.

In general, flow meters of some kind are used to check the performance of the turbine but, for reliable results and turbine tests, condensate measurements are preferred.

In Fig. 1, the location of meters, gages and thermometers on the steam lines of the 1927 extension to Toronto Station are shown in considerable detail. Starting from the boiler, the steam pressure and temperature of the steam at the boiler outlet are taken by recording instruments located in the mechanical control room. At the steam heater, pressure and temperature recorders are installed with the recorders installed in the boiler room and with a duplicate pressure recorder in the control room.

Provision for Checking Should Be Made

Each boiler is equipped with a steam flow meter for checking the delivery and, what is of extreme importance, thermometer test wells and taps for pressure test gages are installed so that the recording instruments can be checked periodically so as to insure their accuracy. A recording thermometer and test well as also located at the turbine throttle.

This turbine is a 33,000-kw., 17-stage, 1800-r.p.m. unit bled at the 7, 11 and 15 stages for feedwater heating and operating evaporators. Each heater line is equipped with indicating thermometers and pressure gages on the heater side of the check valves in addition to a pressure gage on the turbine side. A closed valve or undue resistance through the check valve would cause a pressure differential which would be noticed immediately.

In the line to the evaporators, a flow meter is installed for test purposes. Referring to Fig. 2 showing

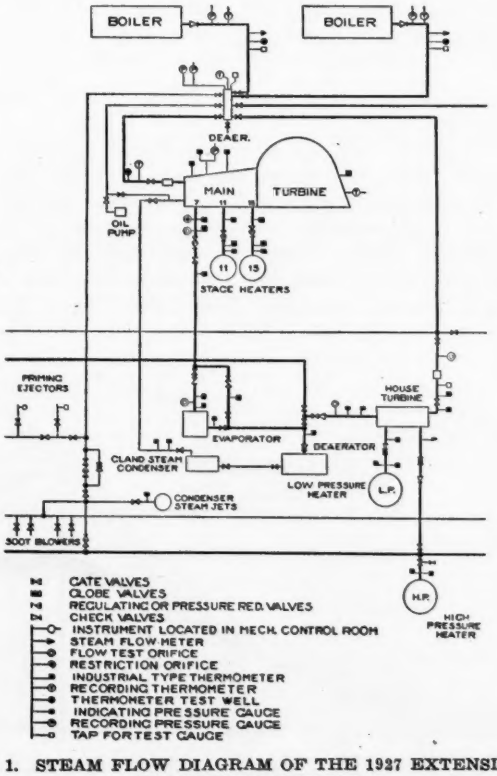


FIG. 1. STEAM FLOW DIAGRAM OF THE 1927 EXTENSIONS TO TORONTO STATION

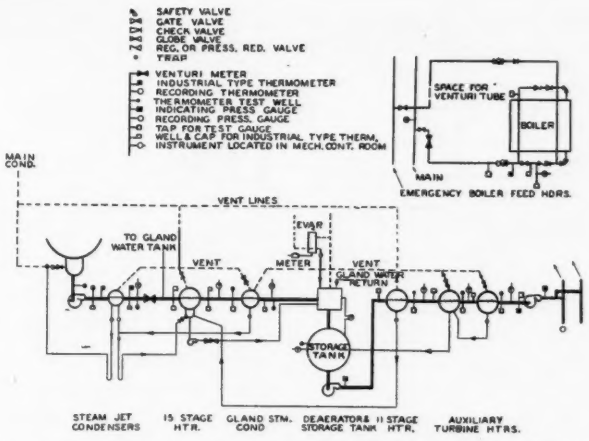


FIG. 2. BOILER FEEDWATER DIAGRAM OF UNIT NO. 4 AT TORONTO STATION

the condensate and boiler feedwater system for the same station, it will be seen that condensate from the stage heaters is cascaded to the condenser and later measured by the venturi meter installed just before the 15-stage heater. Obviously the sum of the condensate meter reading and the evaporator meter reading will give the total steam flow to the turbine after corrections for condenser leakage have been made. Throughout the balance of the diagram, it is evident that the steam or water conditions can be determined at any point by the operator by means of indicating instruments while the supervisor in the mechanical control room has the essential conditions recorded by instruments located in the control room.

Similar conditions exist in Fig. 4, a diagram combining the steam and feedwater systems of Unit No. 4 at the Hudson Avenue Station. As before, temperature and pressure conditions of the steam leaving the boiler and entering the turbine are watched closely while the steam delivery of the boiler is metered by a flow meter. Here temperatures are obtained by recording instruments but only indicating pressure gages are used.

All Meter Readings Can Be Checked

Recording and indicating steam pressure gages are used at each bleeder heater and recording and indicating thermometers installed at the entrance and exit of each heater to measure the condensate temperatures.

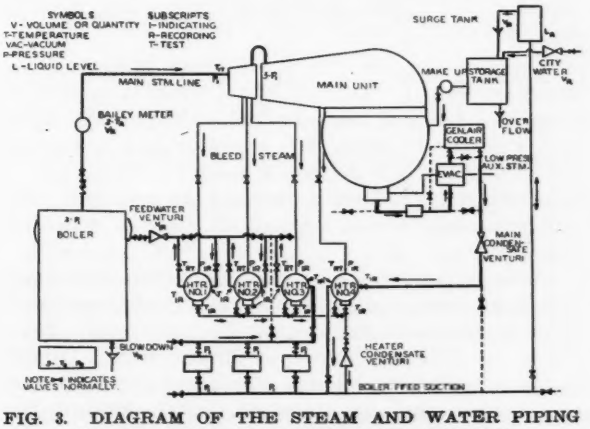


FIG. 3. DIAGRAM OF THE STEAM AND WATER PIPING FOR UNIT NO. 4 AT HUDSON AVE. STATION

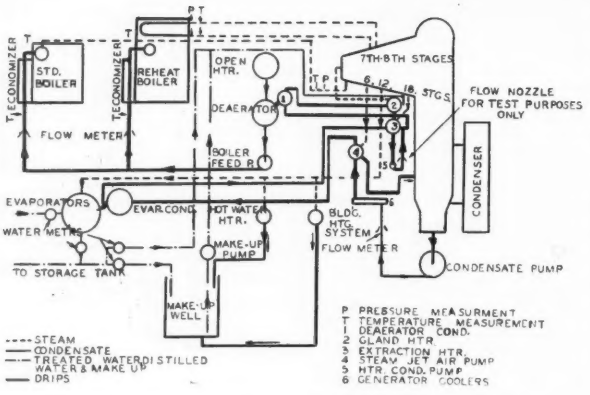


FIG. 4. DIAGRAM SHOWING THE METERING AND INSTRUMENT LOCATIONS AT PHILO STATION

In this way, the temperature gain through each heater and the loss between two heaters is found.

Drips from the heaters are cascaded down to the low-pressure heater and then measured as they are pumped back into the feedwater line. Condensate from the condenser is also measured by a venturi meter. Makeup is supplied to the condenser and metered as it leaves the storage tank. A combination of the volume readings of the two venturi meters and the makeup meter gives the total steam flow to the turbine and in addition shows the amount bled for feedwater heating.

By comparing the two previous mentioned venturi meter readings with the feedwater venturi, the amount of water delivered to the storage or surge tank can be determined. The sum of the feedwater venturi and blowdown meter readings should check the flow meter readings on the boiler outlet and this, in turn, should check the flow to the turbine given by the two condensate meters and the make-up meter.

If there were no steam or water losses from the system except boiler blowdown, the city water makeup should equal the boiler blowdown. Losses and condenser leakage are practically impossible to eliminate. Under similar conditions of operation, the makeup will remain fairly constant in a given power, however, running from one to four per cent in a good modern power plant. In industrial plants, the percentage will be higher, depending upon the amount of steam used for heating or process work.

At Philo, a somewhat different metering arrangement is used as shown in Fig. 4. Here feedwater to each boiler is metered as is the condensate from each condenser. The turbine is bled for the ejectors at the 6-stage for feedwater heating at the 16-stage and for the evaporators at the 12-stage. Condensate from the ejector coolers 4 is drained to the condenser and registers on the condensate meter. Drains from the gland heater 2 and the bleeder heater 3 are pumped back to the feedwater line and can be measured by a flow meter for test purposes, although this is not normally done. Water to the evaporators, to and from the storage tank, makeup well and open heater is also measured. Pressure and temperature readings are taken much the same as in the other installations.

Electric Drive Shows Big Gain

BIENNIAL CENSUS OF MANUFACTURERS SHOWS CONTINUED GAIN IN INSTALLATIONS OF ELECTRIC GENERATORS AND MOTORS

DURING THE TWO YEARS from 1925 to 1927, the total rated capacity of prime movers used in industries of the United States increased 9.2 per cent or some 3,273,619 hp. These figures cover all manufacturing, printing and publishing establishments whose output during the census year was valued at $5000 or more. The data was collected by the Director of Census as a part of the fifth and last biennial census of manufacturers authorized by Congress in 1919. In the future, unless some change is made, this census will be taken only every ten years as during the period from 1870 to 1919.

Data collected since 1870 are shown graphically in the chart, Fig. 1. This shows the gradual growth of power as a factor in the industrial activity of this country. Previous to about 1890, steam engines and water wheels supplied all the power needed. Water power development for industrial purposes has remained practically constant during the past 60 years as shown by Fig. 1.

About 1890, both the internal combustion engine and purchased electric power became factors of importance. Internal combustion engines increased to a peak, 1,241,722 hp. in 1919, but have since decreased to 1,170,759 as shown by the last census. Purchased electric power, on the other hand, has increased steadily until, at the present time, it represents practically 50 per cent of the total industrial power used, being by far the largest single item.

These same data are shown on Fig. 2, plotted in a different form. Comparing the years 1919 and 1927, it can be seen that waterwheels and internal combustion engines have remained practically constant, although the former show a slight increase and the latter a slight decrease. Comparing 1925 and 1927, both show a slight decrease, the figure being 1,800,828 and 1,783,-

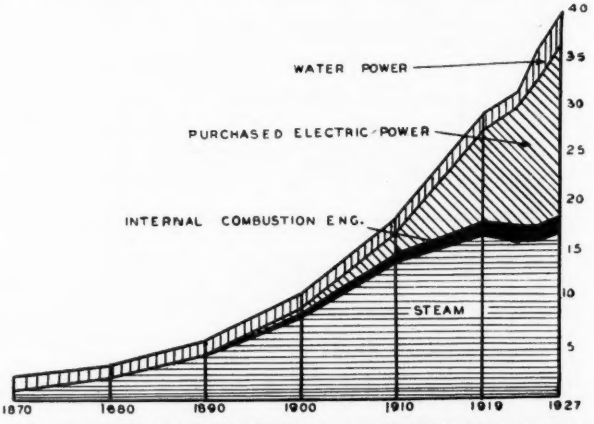


FIG. 1. INSTALLED PRIMARY HORSEPOWER USED IN INDUSTRIES OF THE UNITED STATES

711 for waterwheels and 1,185,738 and 1,170,759 for internal combustion engines.

Total Steam Power Shows Little Change

Steam turbines, on the other hand, show a steady increase of almost 100 per cent since 1919 but this gain has been offset by the continued decrease in steam engines so that the sum of the two representing the power development by steam has remained practically constant at a little below 17,000,000 hp. Since 1919, therefore, practically the entire gain of about 10,000,000 hp. used by industry has been supplied by purchased electric power.

This is shown clearly by comparing G and H of Fig. 2, curve G, representing the motors driven by purchased electric power and curve H, the total installed horsepower. The installation of motors driven by electric power generated within the plant has not lagged far behind, however, and shows a steady increase from 6,968,950 hp. in 1919 to 11,216,111 hp. in 1927. This increase, as shown by curve E, which is almost parallel by curve D, showing for 1925 and 1927 (the only years these data have been collected) the installation of electric generators.

An inspection of curves D and E shows a ratio of connected load to generating capacity of about 1.12 which is quite low. It is probable, although there is no data in support, that the demand factor for these motors is higher than for those driven by purchased power so that a comparison of actual power developed by the two classes of motors might not be as favorable to purchased power as Fig. 3 would indicate.

Further inspection of curves F, D and C, with the knowledge that the number of both turbines and engines is decreasing, indicates that new steam turbines are replacing older engines and that the majority of these new turbines are driving electric generators. Of a total gain in steam turbines of about 1,300,000 hp. from

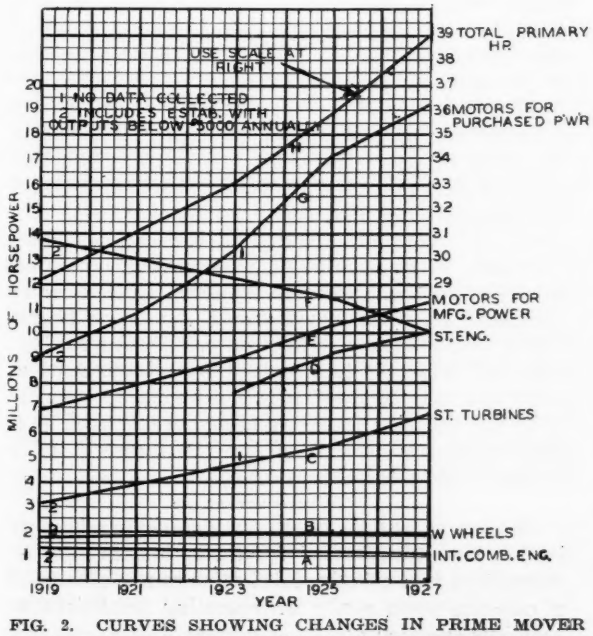


FIG. 2. CURVES SHOWING CHANGES IN PRIME MOVER CAPACITIES IN MANUFACTURING ESTABLISHMENTS WITH PRODUCTS VALUED AT OVER $5000 ANNUALLY

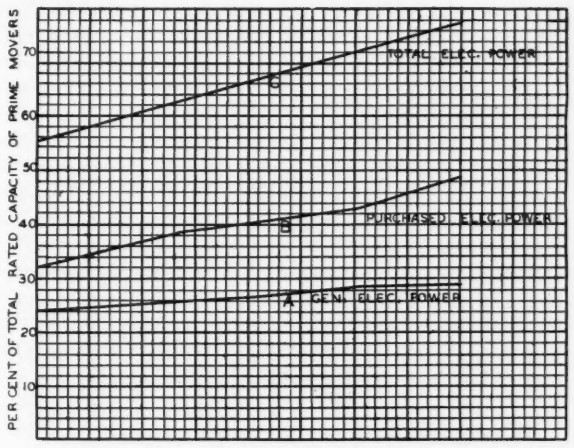


FIG. 3. ELECTRIC MOTOR DRIVE HAS INCREASED 70 PER CENT IN THE PAST 8 YR.

1925 to 1927, about 800,000 hp. are driving electric generators.

Electric Drive Used for About 80 Per Cent of Total Power

Increase in popularity of electric drive is strikingly shown by the top curve in Fig. 3. In 1919, about 55 per cent of the total industrial power was supplied by electric motors driven either by purchased or generated electric power. In 1927, this had increased to almost 80 per cent with no indications that the same rate of increase of about 3 per cent per year would not continue.

Since 1925, the installation of electric motors driven by power generated in the plant, when considered on a percentage basis, has remained practically constant as compared with an increase of about 5 per cent in motors driven by purchased power. That is, in 1925, out of a total rated capacity of 35,766,944 hp. there was installed 10,254,658 hp. of electric motors driven by current generated in the plant. In 1927, out of a total of 39,040,-563 hp., the motor installations had increased only to 11,216,111, giving percentages of about 28.7 and 28.8 respectively, as shown in Fig. 3. During the same period, motors driven by purchased power had increased from 15,864,638 to 19,144,995, giving percentages of about 44.4 and 49.2 respectively.

Of course, considered alone and not in relation to the total power used, motors driven by power generated in the plant increased over 9 per cent while motors driven by purchased power increased about 21 per cent during the same period.

Average Size of Prime Movers Shows Increase

In comparing types of power in this way, it is well to bear in mind the average sizes of the units under discussion. For instance, the average size of the motor driven by purchased power is around 9 hp. while the average size of the motor driven by power generated in the plant is about 50 per cent larger or in the neighborhood of 14 hp.

Sizes of internal combustion engines, steam engines and waterwheels are increasing somewhat, as shown by curves C, D and E of Fig. 4, but not nearly as fast as

the size of turbines or the size of electric generators. An inspection of curves G and F of Fig. 4 and C, D, E and F of Fig. 2, indicates that the larger turbines being installed drive electric generators and that only the smaller turbines are being used for mechanical drive.

When using this data, it must be kept in mind that for 1923, 1925 and 1927 the data includes only establishments whose products were valued at $5000 or over annually while, for 1919, the data includes establishments whose products amount to $1000 and over.

As pointed out by the Department of Commerce, this has only a negligible effect on the comparability of statistics except for the number of establishments. Certainly the effect is not evident on such curves as C of Fig. 3 but is decidedly evident on such curves as E, G

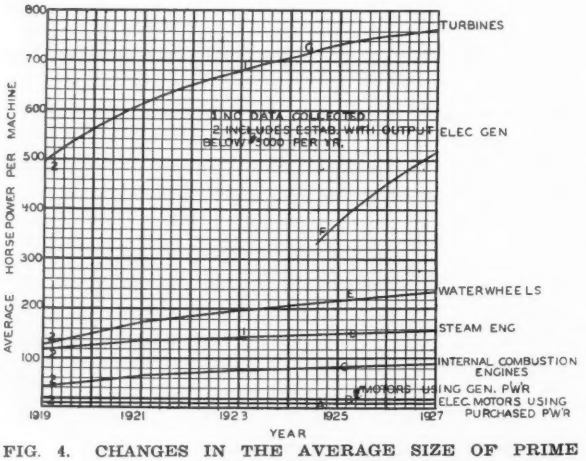


FIG. 4. CHANGES IN THE AVERAGE SIZE OF PRIME MOVERS USED IN INDUSTRIES

and H of Fig. 2. Judging from curve H, Fig. 2, the total rated horsepower in 1919 on the same basis as later years should be between 2 and 3 million horsepower lower than given. For this reason, all the values of Fig. 2 for the year 1919 are probably high while those on Fig. 4 are low.

FOUR METHODS of hand firing are in general use. They are, in the order of efficiency, the ribbon, alternate, coking and spreading methods. By the ribbon method, coal is fired in narrow alternate strips extending the full length of the furnace.

If the width of these strips be extended to half the width of the furnace it is equivalent to the alternate method. Coal is fired on one side of the grate while the other is burning brightly. The coking method is almost equal to the alternate in efficiency. This consists of firing fresh coal to a considerable depth on the dead plate in front of the furnace and allowing it to coke. This coke is then spread evenly over the grate before more coal is fired.

In the spreading method, small quantities of coal are fired at a time, the coal being spread evenly over the entire grate beginning at the bridge wall and working forward. Of course, under certain conditions of furnace design and with various kinds of coal, conditions vary, so that no one method is always superior. The better grades of coal can be fired smokeless by any method but the lower grades with high volatile require more care and skill.

Other Forms of Energy Influence Coal Consumption

TOTAL PRODUCTION of soft coal during the week ending April 6, including lignite and coal coked at the mines, is estimated at 7,627,000 net tons. Compared with the output in the preceding week, this shows a decrease of 317,000 t., or 4.0 per cent. Total production of soft coal during the present calendar year to April 6, approximately 82 working days, amounts to 145,700,000 net tons. These figures are supplied in the latest report of the Bureau of Mines, Department of Commerce.

An important factor in the trend of coal consumption, says the report, is the growth of other sources of energy. It is well known that a rapid increase in the use of petroleum, natural gas and water power has

TABLE SHOWING WORLD PRODUCTION OF ENERGY FROM FUELS AND WATER POWER, 1913-1928

	Trillion British thermal units				Increase 1913–1928 (per cent)
	1913	1920	1923	1928	
Coal					
Bituminous and anthracite	34,946	33,595	34,503	35,338	+ 1 %
Lignite	1,778	2,042	2,144	2,847	+ 60 %
Total coal	36,724	35,637	36,647	38,185	+ 4 %
Oil and natural gas	2,938	5,030	7,081	9,536	+ 225 %
Water power	1,750	2,660	3,580	4,660	+ 166 %
Grand total	41,412	43,327	47,308	52,383	+ 26 %

tended to limit consumption of coal. This is true not only in the United States but in many other countries. The condition is essentially world-wide, as is shown by the accompanying tabulated preliminary analysis of world supplies of energy in 1928. In order to compare the several sources of energy, it is necessary to express them in terms of a common denominator. This is done in the table, which shows the energy equivalent in B.t.u. of each of the fuels. Water power is represented by the equivalent of the fuel necessary to perform the same work. The total of the energy from all sources in 1928 amounted to 52,383 trillion B.t.u.'s in comparison with 41,412 trillion in 1913. Thus while the production of coal itself has increased only 1 per cent since 1913, the total production of energy has increased 26 per cent.

Clearly much of the extraordinary increase in the other sources of power does not represent direct displacement of coal. The refined products of petroleum and even a large part of the fuel oil have been used for purposes that raw coal could not readily meet. Even motor fuel, however, involves an invisible competition with coal. If gasoline had not been available, the need of a system of light transportation would doubtless have stimulated alternative means, such as electric traction, driven by coal-generated electricity. It is interesting to note that while the total energy from bituminous and anthracite coal increased only 1 per cent, between 1913 and 1928, the total energy from lignite increased 60 per cent, chiefly on account of the rapid growth of the German lignite industry.

SELECTION OF LUBRICANTS for high temperature service has been transformed from a hazardous hope to a proven fact that effective lubrication can be obtained by a common sense study of operating conditions and judicious selection of oils or greases with a proper degree of refinement.

New Test Code for Heating Boilers

STANDARD TEST METHODS ADOPTED BY NATIONAL BOILER & RADIATOR MFG. ASSN.

STANDARD TEST CODES have done much to improve engineering standards in this country by allowing tests made in different parts of the country to be compared directly. One of the latest codes just made available to the engineering public is the new code for testing solid fuel burning, low-pressure steam boilers.

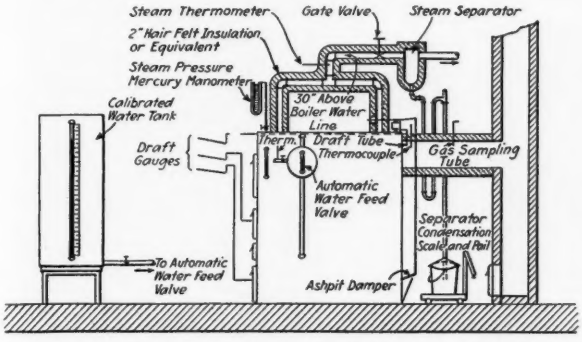


FIG. 1. APPROVED ARRANGEMENT OF TEST APPARATUS

Arrangement of the apparatus should be as shown in Fig. 2 and the minimum equipment necessary is as follows: scales, calibrated water tank, steam and water thermometers, steam pressure manometer, draft gages, pyrometer, CO_2 and CO apparatus and barometer.

Location of the flue gas thermocouple and gas sampling tube should be as shown in Fig. 2. In common with other low-pressure boiler heating codes, the location of the thermocouple with reference to the smoke hood or collar is not specified and recent experiments by the Bureau of Mines indicate that an appreciable error may be introduced because of stratification if the distance is not carefully selected. Tests made of boilers with flues from 5 to 30 in. in diameter and with gas temperatures of from 400 to 1000 deg. F. showed that there was considerable stratification of the gases and that the temperature at the center of the pipe was high; however, fairly good mixing is obtained in a travel of 4 pipe diameters.

Five tests are specified at 2 lb. pressure, one at the drive output or maximum rating and four at other outputs so as to cover the entire range of the boiler. No tests in which more than a net of 2 per cent of the water fed to the boiler is collected from the separator shall be used. For boilers up to 3000 sq. ft. of steam radiation, an automatic feed valve of the slow feed type which will maintain a constant water level shall be used; for larger boilers, the feedwater may be regulated by a gate valve.

Boilers shall be cleaned with sal-soda or lye, washed and filled with clean water before starting the test. Each test shall be continued until at least 250 by the continuous fire or 150 by the new fire method lb. of coal per sq. ft. of grate area have been burned.

At regular intervals, not greater than 15 min., the following data must be recorded: water evaporated, temperature of feedwater, steam temperature, steam pressure, drafts in ash pit, fire box and smoke outlet, temperature of gases leaving the boiler, water collected from separator. In addition to these the boiler room temperature, outside temperature and barometric pressure must be recorded each hour. Smoke observation, using the Ringelmann chart, must be recorded every 15 min.

Data collected should be recorded on a standard test form. A total of five standard forms are provided. Forms A and B are boiler room log sheets for recording readings during the test; A is for the new fire methods and B for the continuous fire method. Form C on the back of A or B is used for recording weights of fuel, residue and gas analysis. Results of all tests are reported in summary on Form D and plotted as curves on Form E. Form E shows the boiler and grate efficiency, temperature of flue gases, average firing interval, average attention interval and draft. Attention to the fire may be firing, stoking, leveling or shaking the grate.

Computations and explanations of test data and formulas and definitions of terms used are given in considerable detail. The overall or boiler and grate efficiency is the percentage of heat, in the net dry fuel burned plus the heat in the fuel fallen through the grate, delivered at the boiler nozzle when the boiler is normally insulated. The square foot of steam radiation is defined as a heat input of 240 B.t.u. per hr.

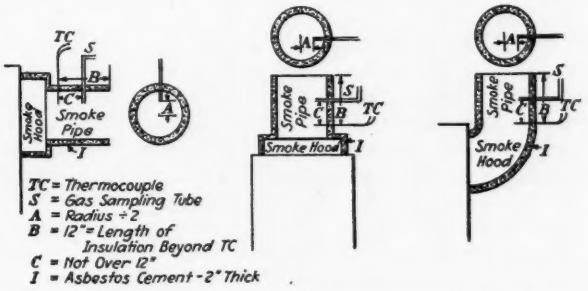


FIG. 2. LOCATION OF FLUE GAS THERMOCOUPLE AND GAS SAMPLING TUBE

FOR MULTIPLE EXPANSION engines, the cylinder ratio is the relation of the displacement of the low-pressure piston to that of the high pressure. As the stroke is the same in both cases, the ratio is the square of the low-pressure cylinder diameter divided by the square of the high-pressure cylinder diameter. In practice, this will range from 2.5 for noncondensing engines up to four, five or even six in condensing engines.

The ratio of expansion or the number of expansions of the steam is the ratio of the volume of the low-pressure cylinder to the volume in the high-pressure cylinder at cutoff. It is, therefore, easy to prove mathematically that the expansion ratio is the product of the number of expansions in the high-pressure cylinder and the cylinder ratio. As the number of expansions in the high-pressure cylinder is the reciprocal of the cutoff in per cent, a more useful expression for expansion ratio is the cylinder ratio divided by the cutoff of the high-pressure cylinder.

Many Uses for Power in New Building of the N.Y. Life Insurance Company

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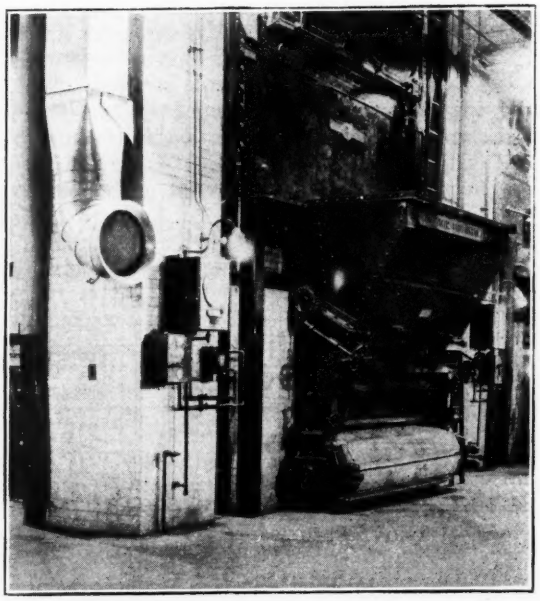


AMONG THE MANY new buildings of New York City, one of the most dignified and imposing in architectural design, is the new office building of the New York Life Insurance Co. This building, which is faced entirely with Indiana buff limestone, and which rises 617 ft. above the sidewalk, is well fitted to occupy the block between 26th and 27th streets on 5th avenue, made famous by Madison Square Garden. The building was designed by Cass Gilbert.

With a rentable area of 925,000 sq. ft., distributed over some 34 floors, the power and service requirements for this structure are considerable and varied, and to satisfy these requirements, a great amount of mechanical and electrical equipment is installed. On the ventilating system alone there are 56 motors driving 29 blowers and 27 exhaust fans. Elevator service is furnished by 31 high speed passenger cars, four special cars for officials, etc., two high speed freight, and one low speed freight elevator. Altogether, some 4000 hp. in motors is installed.

Steam for heating, for kitchen service and for hot water requirements is generated in five 400-hp. water-tube boilers fitted with chain grate stokers. These are installed in the fourth basement. Coal is supplied by an automatic coal handling system which transports the coal from the receiving hopper at street level to the automatic weigh larry in the boiler room. This system consists of a wagon hopper, chutes, feeder, mechanical weightometer, main distributing conveyor and trimming conveyor.

In addition to the boilers, in the fourth basement are also the cold water pumps, the vacuum pumps, air compressors and general service pumps. This equipment is installed in three separate rooms, the cold water pumps in one, the vacuum pumps and air compressors in another, and the service pumps in a third. The pumps are all of the centrifugal type and all driven by electric motors, controlled automatically by magnetic contactors operated by float or pressure as the case may be.

A complete refrigerating plant is installed in the 5th basement. This consists of three 9 by 9-in. and one 5 by 5-in. ammonia compressors, belted to 75-hp. and 15-hp. motors respectively, together with the necessary condenser, brine pumps, and an ice making tank capable of making 4 t. of ice daily.

The ventilating system is unusually complete and well designed. With it one million cubic feet of air is supplied every minute. The tempering stacks are all of the Vento type, there being a total of 20 systems with a total radiating surface of 35,520 sq. ft.

Fans and blowers are all of the full housing type and with a few exceptions are all direct connected to the driving motors. The fan capacities vary from 500 c.f.m. to 107,250 c.f.m. most of the units being rated around 30,000 to 40,000 c.f.m.

An exceptionally fine steam flow meter installation is a feature of the boiler room. These measure the steam, to the various divisions of the heating system, the hot-water generators, the barber shop and the kitchens. These flow meters are installed on the rear wall of the boiler room and are shown on the opposite page.

The most striking feature about the mechanical equipment installed in this building is the automatic control. Manual operation has been cut down to the absolute minimum. Every pump, every compressor, in fact every piece of equipment which does not absolutely require hand operation is controlled automatically.

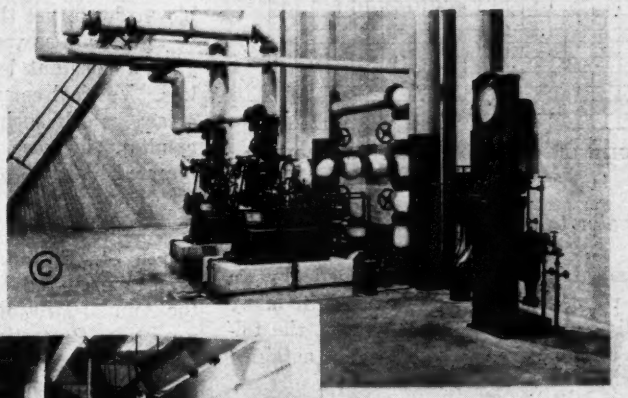
While most of the mechanical equipment as well as the boilers is installed far below street level away from all sunlight, the power plant is provided with an abundance of illumination by incandescent lamps, as may be noted from the photographs on the opposite page. Another admirable feature about the plant is the abundance of space. More than ample space has been left around all machinery so that there is plenty of room to move about. This is a feature not often encountered in office building plants.

All equipment has been installed in accordance with the most modern requirements and while efficiency of operation has been kept in mind, reliability of service was one of the first considerations in the installation of each piece of equipment.

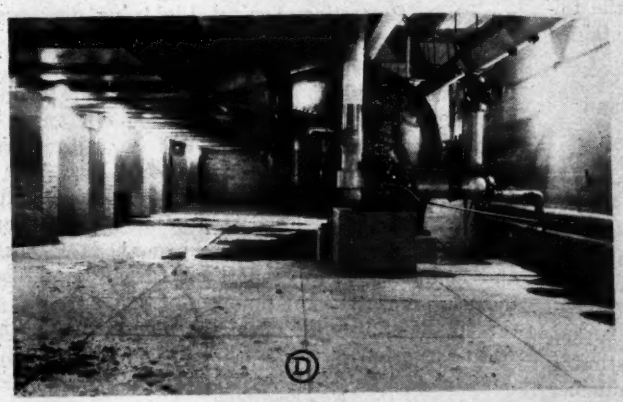
Views of Equipment at N. Y. Life Bldg.

A. View behind the 5-400 hp. boilers showing motors driving stokers. Note boiler meter installation on wall, measuring steam and water flow to various services.

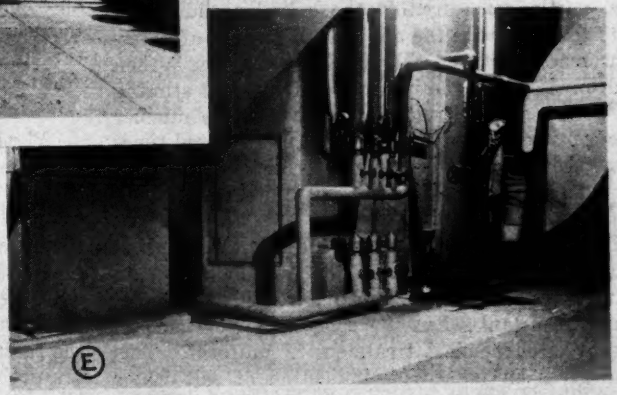
B. The firing aisle with automatic weigh larry at further end.



C. The two single stage centrifugal boiler feed pumps and the Venturi meter.



D. In the fifth basement, showing one of the three 20,000-c.f.m. forced draft fans and the duct leading to the stoker hoppers.

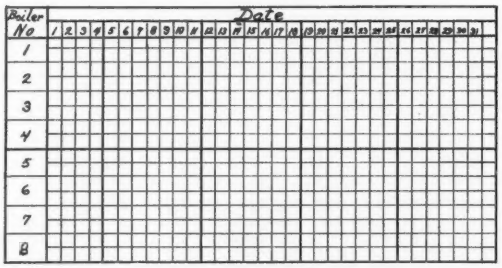


E. This is one of the 56 fan installations for supplying ventilation to the N. Y. Life Insurance Co. Building.

Regulate Your Boiler Blowdown by Tests

SIMPLE TESTS PERFORMED BY OPERATORS RESULT IN INCREASED ECONOMY. BY A. H. MOODY*

EXPERIENCE has definitely shown that high concentrations of dissolved or suspended solids in the boiler water of steam power plants are conducive to priming, foaming and scale formation. The method most commonly used to reduce the concentrations is that of blowing down the boilers. Unless some means is used to determine the necessity and effectiveness of the blowdown, such practice leads to excessive makeup with consequent loss of efficiency on the one hand, or scale formation and poor quality of steam on the other. Even with continuous blowdown, tests should be made on the resulting boiler water to determine the economy of the system.



CONVENIENT FORM OF RECORD CHART FOR BOILER BLOWDOWN

A simple chemical test which can be made by an instructed boiler room operator may be used in many cases for controlling blowdown. For this test, the following apparatus and chemicals which may be obtained from a chemical supply house are necessary:

50 c.c. measuring burette with clamp and stand
50 c.c. graduated glass cylinder
250 c.c. Erlenmeyer flasks
½ per cent solution of potassium chromate
2½ per cent solution of silver nitrate

From the blowdown line, a sample of water is taken, a 50-c.c. portion measured in the cylinder and transferred to the flask with the addition of one c.c. of potassium chromate solution. Silver nitrate solution is then added dropwise from the burette with constant stirring until a permanent red color is obtained. The number of cubic centimeters of silver nitrate solution used times 500 gives the amount of sodium chloride in the sample in terms of parts per million, or, multiplied by 29, gives grains per gallon.

While the ratio of sodium chloride to total dissolved solids is not always a constant, the test does serve to give a measure for blowdown control. This ratio will hold fairly constant when the composition of makeup is constant and chemical treatment is uniform. This test also gives an immediate indication of salt water surface condenser leakage—as shown by a large and sudden increase in the salt content of the boiler water.

*Chemist, Hell Gate Station, The United Electric Light & Power Co., New York, N. Y.

Convenient records of boiler blowdowns and salt tests may be made on a form similar to the accompanying boiler blowdown chart. Spaces are provided for daily notation, both for salt readings and for blowdown on each boiler. On the chart, a number representing the cubic centimeters of silver nitrate solution, or parts per million, or grains per gallon, is placed in the upper box opposite each boiler number and under the corresponding date. Should this number exceed a certain prescribed maximum, instructions are given to the operating men to blow down that particular boiler. Blowdowns are continued on that boiler until subsequent tests show the concentration below the dead line. A record of boilers blown down is made from the boiler room log book by placing a check mark under the salt reading for that day on the boiler blowdown chart.

Maximum allowable salt content must be determined by experience and should be at a point somewhat below that causing wet steam, corrosion or scale. This may vary with different boilers, due to difference in design or operating conditions.

Comparison of readings horizontally will indicate how a certain boiler is responding to blowdown treatment. In one case, it was found that a certain boiler was never blown down, yet the salt content did not increase. Investigation discovered a leaky blowdown valve, which gave a constant leakage with consequent unnecessary loss. Vertical comparison will indicate any sudden increase in salt such as from condenser leakage, with a resultant increase in number of boilers exceeding the imposed limit.

NATIONAL FIRE PROTECTION ASSOCIATION, 60 Batterymarch St., Boston, Mass., has issued copies of several reports prepared by its committee for presentation at the Annual Meeting held at Memphis, May 13 to 16. A report on Protection Against Lightning discusses protection of persons, buildings and miscellaneous property, smoke stacks and chimneys, radio installations, ships, live stocks, and so on. Fundamental principles of lightning protection are discussed and the various precautions and equipment that can be utilized are described. Another report on First Aid Fire Appliances discusses installation and use of standpipe and hose systems and fire extinguishers of all kinds, describing the various types that are used, methods of operation and maintenance. A report on Fire Pumps discusses the use of centrifugal pumps for this purpose, giving the details of installation of the pumps, driving motors and accessories.

WELDING PROCESSES liberate considerable visible radiant energy which workers should be protected against. This is particularly true of arc welding which is rich in ultra violet rays. For the protection of eyes from these rays, black, amber, green and greenish yellow glasses are best. For protection against the infra red rays, deep black, yellowish green, sage green, bluish green, and gold plated glasses are best. The greater the radiance, the darker the glasses should be. The best are probably black, green, and yellowish green, as these not only cut down the light but protect against both the ultra violet and infra red rays. With the arc, all parts of the body should be protected and workers should wear helmets, shields and high gauntleted gloves.

Calderwood Development on Little Tennessee

COMPENSATED ARCH DAM WITH CUSHION POOL, CONCRETE-LINED 2200-FT. PRESSURE TUNNEL, REMOVABLE RACK STRUCTURE, THREE 56,000-HP. TURBINES FORM FEATURES OF PROJECT

KNOXVILLE POWER CO., with general offices at Pittsburgh, Penna., is now developing a 168,000-hp. hydroelectric project on the Little Tennessee River, located about six miles below the North Carolina-Tennessee state line and scheduled for completion in January, 1930.

Figure 1 shows the general arrangement of the main dam, secondary dam, tunnel and power house. Water

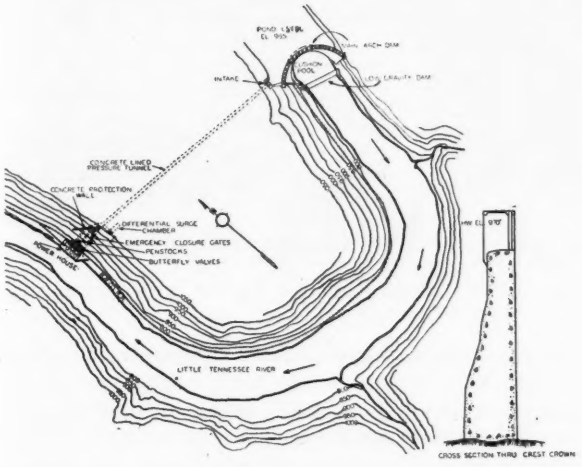


FIG. 1. GENERAL ARRANGEMENT OF DAM, CUSHION POOL, TUNNEL AND POWER HOUSE AT CALDERWOOD DEVELOPMENT

from the reservoir created by the main dam will be conducted by a tunnel through a horseshoe bend of the river to the power house, located about one mile above the town of Calderwood, Tenn.

Main dam is of the compensated arch type, designed to avoid tensile stresses in the concrete and to carry its loads in the most efficient manner. The dam rests on massive ledges of arkose, a hard, coarsely-granular metamorphosed sandstone; about 370,000 cu. yd. of overburden were removed to insure perfect foundations. The dam will be 210 ft. high, measured from the floor of the operating platform over the flood gates to the bed of the river. A cross-section of this dam at the center of the river is shown in Fig. 1.

FLOOD WATERS DISCHARGE TO CUSHION POOL

An unusual feature in design is that flood waters will be discharged directly over its crest with a free drop into a cushion pool, formed by a secondary, gravity type, concrete dam, of about 40 ft. maximum height. With the expected maximum discharge of 200,000 sec. ft., the depth of water on the crest of the secondary dam will be 30 ft. and the maximum depth of the cushion pool will be 70 ft. It will be noted that flood water passing over the main dam will have a clear drop of about 130 ft. before it reaches the static level of the cushion pool; in other words, the ratio of the free fall to the cushion pool depth is about two to one.

Flood flows will be controlled by 24 Stoney type flood gates, each 25 ft. wide by 20 ft. high, located on the crest of the dam at the downstream end of the piers. The flood gates will be maneuvered by two gantry cranes, each of which can be shifted over any gate. A coupling device has been designed to connect the crane hook to the gates automatically and almost instantaneously, thus reducing to a minimum the time required to shift from one gate to another.

INTAKE AND HEADWORKS

The tunnel intake, located immediately upstream from the main dam, is provided with a trash rack and head gates. An unusual feature in the design of the rack structure is that all metal work, including the

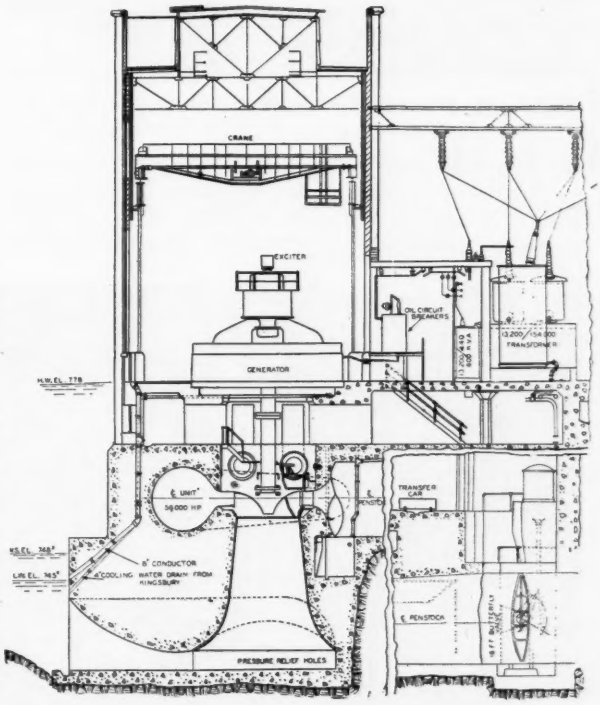


FIG. 2. CROSS-SECTION THROUGH POWER HOUSE

rack sections and their supporting beams, may be removed for inspection, repairs or replacements, as may be desired. The head gates are 15 ft. 9 in. wide by 24 ft. 6 in. high and are of the Stoney type.

The tunnel, some 2200 ft. long, will be lined throughout with concrete averaging 18 in. in thickness. The tunnel, in the shape of an inverted U, is 26 ft. wide at the bottom by 24 ft. high. A differential-type surge chamber was provided at the downstream end of the tunnel by excavating a gallery in the mountain side.

The power house end of the tunnel is manifolded into three penstocks, each 16 ft. in diameter. The upstream end of each penstock is arranged to receive a

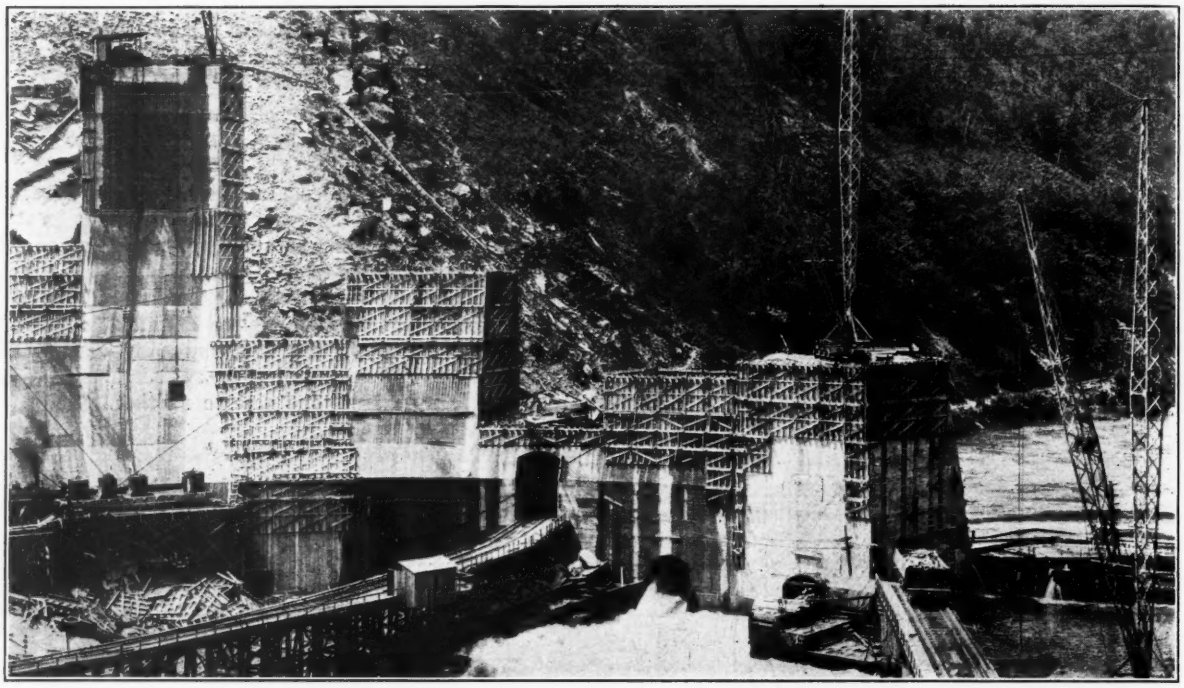


FIG. 3. AS THE MASTS OF THE DERRICKS USED ON THE DAM AT CALDERWOOD ARE 110 FT. HIGH, THIS VIEW GIVES SOME IDEA OF THE MAGNITUDE OF THE PROJECT

hemispherical service gate, which ordinarily is pocketed in a recess at one side of each penstock. This arrangement will enable repairs to be made to the penstock butterfly valves without keeping the tunnel drained for an unreasonable length of time. The lower end of each penstock at the inlet to the turbine scroll case may be closed by a 16-ft. Allis-Chalmers, hydraulically-operated, butterfly valve, controllable from the switchboard.

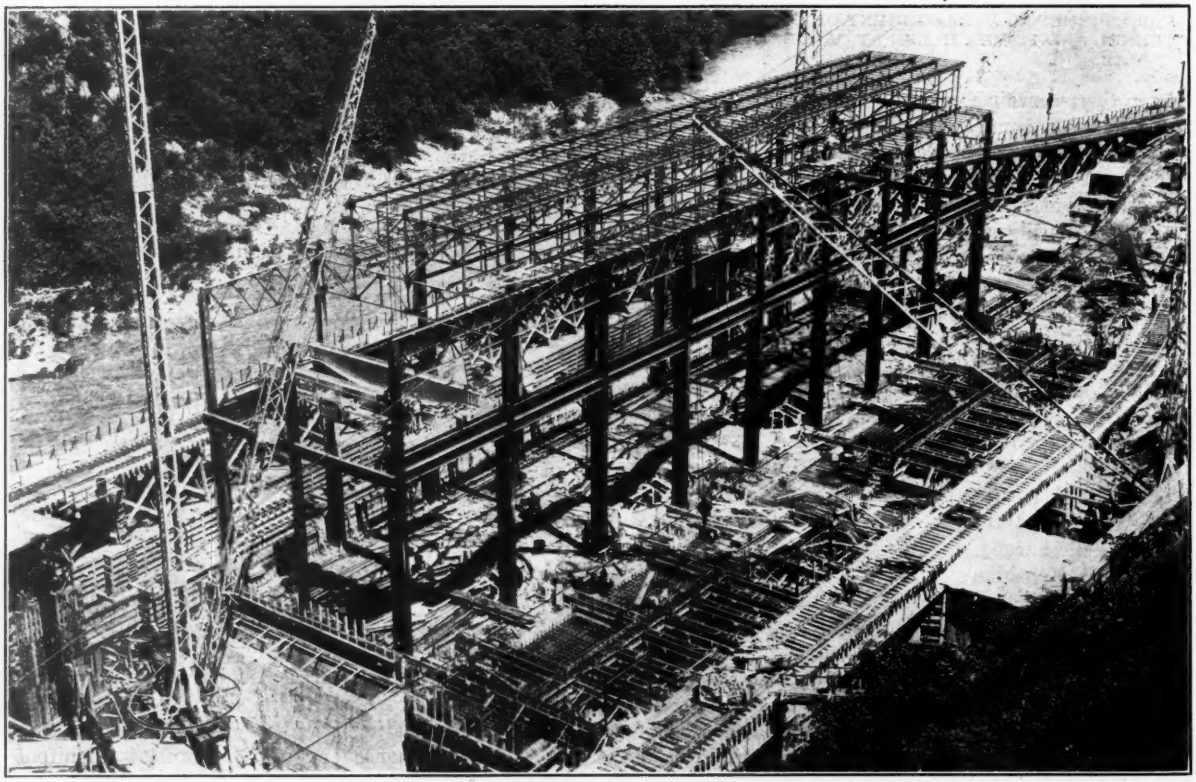


FIG. 4. RECENT VIEW OF CONSTRUCTION WORK ON POWER HOUSE WHICH WILL HOUSE TWO INITIAL 56,000-HP. UNITS; A THIRD UNIT LATER WILL RAISE THE CAPACITY TO 168,000 HP.

POWER HOUSE DESIGNED FOR THREE 56,000-HP. UNITS

Ultimately, the power house, shown in cross-section in Fig. 2, will contain three units, two of which are now being installed, together with the essential parts of the third unit, which will be completed when conditions warrant. Each unit consists of an Allis-Chalmers standard vertical Francis-type turbine, designed to develop 56,000 hp. at 150 r.p.m. under 213 ft. head. The draft tubes are of the white hydraucone type; Allis-Chalmers governors are used. The generators, made by Westinghouse Electric & Manufacturing Co., are rated at 45,000 k.v.-a., 13,200 v., 3 phase, 60 cycles. Cooling-air for the generators is drawn from the turbine floor, passed through the generators and exhausted through the roof.

The detailed plans for the complete development were prepared in the Pittsburgh Office of Knoxville Power Co. The hydraulic end of the entire project is under the direction of James W. Rickey, chief hydraulic engineer of the company, assisted by J. P. Growdon, principal assistant; the electrical end is under the direction of T. J. Bostwick, chief electrical engineer. F. W. Hanna and Lars Jorgensen acted in the capacity of consulting engineers on the main dam.

Coal to Fit the Plant

BY LEROY BLAKE

IN OUR PLANT of two 72-in. horizontal return tubular boilers, the natural draft is 0.35 in. of water over the fire. Due to peak load steam demands, we had used a high volatile coal but decided to do some investigating as to efficiency.

The gas analyses at various times showed CO from 0.05 to as high as 3.5 per cent, so we put a water meter on the job and ran an evaporation test. For the coal used, designated as No. 1, we got actual evaporation of 8.07 lb., equivalent from and at 212 deg. of 8.77 lb. and a combined grate and boiler efficiency of 59.9 per cent. The stack smoked during the entire 11-hr. run, hence loss could readily be attributed to high CO in the flue gases.

Because of the peak load situation, for which steam demand was met with difficulty, inclined hand stokers were decided upon. It was felt that the pitch of the grates would give larger furnace volume, the larger grate area would permit a slower rate of combustion and more time for burning the gases and fires could be easily cleaned during the run, which was desirable on account of the high ash content, (10 per cent) of the coal.

Proposals for two different hand stokers specified 10.5 lb. equivalent evaporation, with coal of 14,400 B.t.u. heat content. The first one, when installed, helped cut down smoke but failed to aid the peak load difficulty.

During a year, another coal was tried with lower volatile and ash and the second stoker showed, on test with that coal, actual evaporation of 9.38 lb., equivalent evaporation of 10.05 lb. and overall efficiency of 66.3 per cent. But the smoke was as bad as in the test with No. 1 coal.

Meanwhile load had increased so that there was as great difficulty as ever in handling the peak. So a third coal, quicker burning but with the same volatile as No. 2 was tried. Test showed an actual evaporation of 10.41 lb., equivalent evaporation of 11.27 lb. and efficiency of 74.3 per cent. The cost of this coal was some 7 per cent higher than for No. 2 so that the economy was doubtful.

Another coal, No. 4, was offered at 25 cents a ton less than the No. 3. Volatile was some 1.5 per cent lower and ash 1 per cent less but fixed carbon was 2 per cent greater. It was found to make less smoke than any of the others and flue gas analyses seldom showed CO.

While the day's evaporation had increased little, the peak was considerably greater, aggravating an already difficult condition, in maintaining even steam temperature.

So a turbine blower was bought to lessen the handicap of being tied down to one coal and to help meet peak load demand.

After a time, No. 2 coal was offered at a lower price than before and it was tried with forced draft. Here showed up the characteristics that are not revealed by ultimate or proximate analysis. The fuel bed became riddled with holes under forced draft and results were not encouraging.

Later, No. 3 coal was offered at the same price as No. 4 and seemed a "buy" at the price, due to the high evaporation shown on previous test. Several cars were purchased at a time when load was heavy for most of the day. The result was a near disaster.

Ash developed a soft and sticky clinker. It fused first to side and bridge walls, eventually covering the entire grate so that stoker bars became inoperative. Also the fire bed easily developed numerous holes. The only relief was use of the slice bar to open up the grate so as to hold steam at all.

Another coal, No. 5, was offered at lower price, with lower volatile, higher ash and moisture and lower heat value. It required blowing all the time, regardless of steam demands and had a slow heat releasing rate.

Since No. 1 coal was out of the question due to poor economy, this left No. 4 coal as the logical choice. This had a peculiar granular structure that seemed to fit the forced draft conditions, allowing a steady heat release at all boiler outputs and meeting fluctuations dependably.

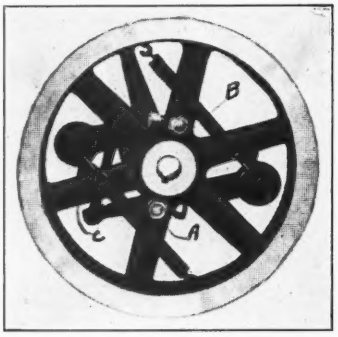
Results and characteristics of the coals are shown in the table.

	No. 1	No. 2	No. 3	No. 4	No. 5
Moisture %	3.00	2.00	1.00	1.00	2.00
Volatile %	34.00	20.00	20.00	17.50	16.25
Fixed Carbon %	55.00	70.00	73.00	75.00	74.00
Ash %	10.00	5.50	6.50	5.50	7.50
B.t.u. per lb.	14,200	14,700	14,800	14,500	14,100
Cost per 1,000,000 B.t.u.	$0.228	$0.214	$0.220	$0.216	$0.219
1000 lb. steam.	$0.326	$0.303	$0.277	.....	.....

This experience seems to show that, to match a required steaming rate, the coal best suited is one whose rate of heat release per square foot of grate per hour most nearly matches the desired rate of steaming. It shows that any coal cannot give good results under all conditions and that conditions in a plant require intelligent study so that the right coal may be selected considering price, quality and ability to handle load requirements.

Governor Pin Wear May Cause Wreck and Injury

IN OUR PLANT, we have a small 6 by 5-in. upright engine running at 325 r.p.m. which is supplied with governor and flywheel as illustrated. This engine suddenly acted queerly. It would be running along nicely when suddenly it would begin to act as though the valve



LACK OF ATTENTION TO GOVERNOR PINS CAUSES THEM TO WEAR SO BADLY THAT BOTH ENGINEER AND ENGINE MAY BE INJURED

was sticking. The governor would hammer and pound and the valve jump from one extreme position to the opposite one. The speed regulation was very poor. This engine drives a 36-in. fan and Cole valve for Jones stokers and it must be kept running.

That evening of the day on which the erratic operation was discovered, the eccentric strap was disconnected and the flywheel dismantled from its shaft. A and B in the illustration are governor pins. These are upset on the end extending through the governor arm and threaded for nuts on the other. The hole through which pin A goes was worn elliptical in shape as was also the pin. Pin and hole B were worn not quite as badly, as pin A carries the eccentric arm.

The governor was dismantled, the flywheel lined up in a drill press and the holes reamed. Bushings made of Tobin bronze were pushed into the holes and new pins were made. This cured the trouble.

Wearing of automatic governor pins and bushings, if there are any, is a chronic trouble. When these parts wear, the eccentric begins to roll sidewise, not in the true plane of the valve stem or wristplate and if not attended to promptly is either going to wear out rapidly or break something.

I hope this description will impress others with the importance of looking out for trouble before it develops into a wreck and personal injury as it did in my case.

Minneapolis, Minn. FRED S. RUTLEDGE.

Overcoming Injector Operation Troubles

INJECTORS on steam boilers are sometimes a source of annoyance through failure to give care to their operation. One cause of failure of injectors to lift water is leakage of the steam check valve which thus admits steam to the injector when it is not working. This causes the injector to become heated and when in this condition it is either very difficult to start or it will not start at all. It is necessary, then, to cool it before starting is attempted again and this is usually done by drenching it with cold water. The steam check valve should therefore be kept tight and leakproof and closed when not working.

Another cause of overheating is conduction from the hot boiler. This sometimes occurs, if the injector is situated too close to the boiler. Injectors always work best with dry steam and for this reason the steam supply is taken from the top of the boiler where the steam is driest; if, however, the water level is carried too high the steam will become wet and this may affect the working of the injector.

Excessive back pressure will cause unsatisfactory working. This may be caused by an obstruction in the delivery pipe or by the injector being clogged with deposit due to operation with impure feedwater. To prevent dirt and grit being sucked up, a wire gauze filter is placed over the end of the suction pipe. This should be examined occasionally to see whether it is still intact and it should be cleaned of any slime which may have collected. Where the feedwater carries a large amount of impurities in solution, these impurities may settle out in the injector and its connections and clog them, causing the injector to overheat and work badly. In such cases, it is advisable to keep a spare injector on hand to replace any one which becomes clogged, so that it may be cleaned at leisure.

Another cause of defective working is a leak in the suction pipe. The best way to detect such leaks is to plug up the suction pipe and turn on the steam. The leak will be indicated by the steam which will escape. Before installing an injector, full data regarding its

connections should be obtained from the manufacturer. Improper working of injectors may often be traced to the connecting pipe work being improperly installed and causing excessive back pressure.

Brentford, England. W. E. WARNER.

Washing a Horizontal Tubular Boiler

I WOULD NOT operate the compressed air tank, illustrated in the July 1 issue by R. F. Leach and used in connection with a kerosene spray for the purpose of removing boiler scale, unless it was properly equipped with a reducing valve, pressure gage and release valve.

I am very suspicious of compressed air. It has the features of something innocent and harmless but really contains qualities that are extremely dangerous. An operator not far from here, while emptying a barrel of oil by means of compressed air, allowed the pressure to build up, through lack of proper accessory equipment. The drum was blown through the floor onto the roof and the operator was killed.

There are two objections to the method suggested by Mr. Leach. One is that the operator is assuming an unnecessary hazard in the use of kerosene or other oil, from explosion that might follow an accumulation of fumes inside of the shell. The other objection, in our plant, at least, is that it would cause considerable delay and waste of time in waiting for the scale to absorb the oil. Our plant runs five days a week and we do our washing on Saturday morning. The longer time required by Mr. Leach's method might interfere with our Saturday afternoon off.

We are operating 200-hp. h.r.t. boilers and they are now 22 yr. old. There has never been a fire tube replaced nor has a single leak occurred except, at one time, around the heads of some of the stay rods. These boilers are absolutely clean. Our makeup water is 100 per cent and contains as high as 24 gr. of hardness. We are not claiming this as a record nor proclaiming it as a mystery. The secret is in an analytical control of the boiler water.

I would suggest that Mr. Leach get in touch with some reliable water treatment concern and let them show him how to prevent the formation of scale, before he blows up a boiler from accumulation of fumes from the use of kerosene as a solvent.

Anderson, Ind. GEORGE S. BILLMAN.

Refrigeration Compressor Pressure Reduced

AS ECONOMY of power in refrigeration requires as low head pressure as possible and the head pressure is determined by the temperature of cooling water available, it is worth while to study methods of lowering that temperature.

Where water supply is limited, it must be recooled by cooling tower or spray pond. If well water is of ample amount, it is better as it will be of lower temperature but effective spraying is important when recooling is necessary.

At the plant of Granite City Ice Co., Quincy, Mass., the use of two 4-in. pumps to handle 1000 g.p.m. against 12 lb. pressure at the spray nozzles permitted reduction of 15 lb. in compressor pressure. The original installation was for 200 g.p.m. and the increase in capacity of the plant paid good returns on the cost of pumps and operation.

B. M. CHESTER.

Sturdy Pair of Carpenter Horses

MOST POWER PLANTS or shops can use a pair of carpenter's horses and indeed few places are without these handy accessories. The trouble with most carpenter's horses, however, lies in the fact that they are usually made of wood and have a tendency to break or spread after they have been subjected to any hard usage.

The plant welder of a large Eastern shop, realizing these facts, constructed a pair out of some scrap angle iron. The finished product was an agreeable surprise

WELDED STRIPS OF STEEL MAKE UP CARPENTER'S HORSES THAT ARE NOT READILY DAMAGED

to the carpenter's gang and a great improvement over the wooden ones that had been used in the past.

It was a simple task to weld these pieces of scrap together. The accompanying illustration clearly illustrates the construction of the horse and the location of the welds. The pieces were all welded with butt-type joints and a small amount of welding rod added for extra strength.

FIELD EDITOR.

Why Wet Ashes in Ash Pit?

SOME ENGINEERS seem to think an ash pit is a place in which ashes are to be kept instead of a place from which they should be removed. If the ashpit is kept empty, the grate bars will last indefinitely while, if it is kept full, the bars may burn out in less than a week.

Some persons fool themselves by keeping a "fish-pond" in the ashpit, several inches of water being kept there so that ashes are quenched at once when they drop. One engineer declared he had made his ashpit water tight and rigged a connection to the boiler feed pump so that he could fill the ashpit with water as it evaporated. The try-cock drip and water column blow-off were also piped to the fish-pond.

But our engineer finally did a lot of thinking and then determined to see whether soaking ash is an economic procedure. He therefore filled the ashpit with water up to a certain reference mark, then, after oper-

ating the boiler for several hours, refilled the ashpit to the same mark but this time, he did it with a gallon measure instead of from the feed pipe. He thus determined the approximate amount of water evaporated from the ashpit during a day's run.

It requires 971.7 B.t.u. to evaporate water at 212 deg. to steam at the same temperature. If we add to this heat necessary to raise the water to 212 deg. temp. and that necessary to superheat it to the temperature of the flue gases, we find that the total heat required to turn the water into steam is about 1300 B.t.u. per lb.

On one occasion, in working out his problem, the engineer found that 54 gal. of water were required to replace the lowering of the ashpit water level by evaporation. This amounts to $8.345 \times 54 = 450$ lb. water. Allowing 12,000 B.t.u. as the amount of heat given off in the combustion of each pound of fuel, it would require one pound of coal to evaporate 9¼ lb. of this water. Since a gallon of water weighs 8.345 lb., one pound of coal would evaporate $9.25 \div 8.345 = 1.1$ gal. water and to evaporate 54 gal. would require the combustion of $54 \div 1.1 = 49$ lb. coal.

Coming to these conclusions, the veteran engineer determined henceforth to keep water away from his ashpit as much as possible. He filled up the front portion of his "fish-pond" and formed an incline from the bottom of the ashpit door frame to the back of the pit so that ash and dirt could be drawn out of the pit without the necessity of lifting that material perpendicularly at the door of the pit. The vertical and horizontal corners of the ashpit were also rounded with cement to a 2-in. radius so that material could not cling to the corners of the pit.

Indianapolis, Ind. JAMES F. HOBART.

Boiler Inspection Needed Regularly

FEEDWATER TREATMENT has reached such a state of refinement that in some cases it is now necessary to clean out a boiler only once a year, so far as scale removal is concerned.

Knowing this to be so, some engineers are likely to give the interiors of their boilers less attention than they should receive. In one case of this kind, which was brought to my attention recently, no internal inspection had been made of the boiler for some months. When, at last, the boiler was opened, its interior was found to be coated with oil. Some person had opened a valve on an old pipe line which allowed a return trap handling oily water to deliver its water directly into the feed line to the boiler.

Of course, such an unlocked valve should not have been connected to the line but sometimes, as was the case in this instance, undesirable equipment is left in place instead of being removed when extensive alterations or additions are being made.

Uffington, Ont., Canada. JAMES E. NOBLE.

Leather Packing Tips

HAVE YOU EVER cussed a manufacturer of leather packings for doing a bum job of hole punching? Are you sure, now, that the fault wasn't your own? Probably it was.

Often it is better that the manufacturer punch no holes through leather packing, especially if it is intended to keep the packing in storage for awhile, because even the best leathers shrink or change shape so that, after standing some time, the holes will not match. When the user finds that the holes do not match the bolts, he is, of course, inclined to blame the manufacturer, whereas the manufacturer may be blameless. Therefore, unless the packing is to be used immediately, it is better for the user to cut the bolt holes, himself.

Furthermore, when giving the manufacturer instructions regarding punching bolt holes, be certain that the instructions are complete and accurate. Too often, instructions are so meagre and vague that they cannot be followed by the manufacturer with assurance. He finds it necessary to ask questions or to call for a template.

Newark, N. J. W. F. SCHAPHORST.

Lack of Governor Part Leads to Erratic Action

ONE NIGHT, a couple of years ago, when the temperature was about 25 deg. below zero, the night engineer at our plant called me on the telephone at about 1:30 a. m., saying that the fan engine would not hold its proper speed when steam demands were heavy. He said that he didn't know what was the matter nor could he find out.

I hustled down to the plant and found that the engine would run only at about one-half speed. I, therefore, shut it down and examining the governor, found that the spring that should normally be connected to one of the arms was lying on the floor partly under the flywheel, with the nut and hook bolt which is used to fasten it. One spring did not have tension enough to counteract the weight of the arms when the engine was running. The joke was on the night engineer but the discomfort was on me.

Minneapolis, Minn. FRED S. RUTLEDGE.

Sketch Repair Parts

AN EXCELLENT PLAN, when ordering repair parts, is always to make a rough sketch of the machine or portion of the machine that must be repaired or replaced. It is a simple matter to make a rough sketch, clear enough so that the manufacturer of the machine or part can easily tell what the customer wants. By means of an arrow, point out the part that is wanted. If there is a number on the machine, give the number by all means. The more information given to the manufacturer the better and the more promptly can the repair be made.

Merely to inform the manufacturer that "the cast-iron gear on the north side of the machine we bought from you is broken" is not sufficient. Yet manufacturers commonly receive instructions just as vague as this. Do not use the words right, front, left, or rear unless the machine has a particular right, front, left, or rear. The easiest and best way is to make a helpful sketch even though it may be rough.

Newark, N. J. N. G. NEAR.

IT WAS MANY centuries after the discovery of the attraction of magnets before it was found that they sometimes repel things. After it was discovered that like poles repel each other and unlike poles attract each other, experiments showed that these forces vary inversely as the square of the distance between the poles.

Action of Ammonia and Brine in Ice Plants

WHAT IS the most important thing an engineer of a refrigerating plant should do in case of fire at the plant?

2. What is the life of steel and cast-iron pipe used in brine circulation?

3. What is the life of direct expansion piping used in an ammonia system?

4. Where should the safety valve in an ammonia system be located and at what pressure should it be set?

5. What is the effect of using brine instead of water for cooling an ammonia condenser? R. F. D.

A. The most important thing for an engineer of a refrigerating plant to do in case of fire is to pump the ammonia out of the building in which the fire has occurred, if there are several buildings in the plant, or out of that part of the building where the fire exists, if possible. If the fire should occur directly in the engine room, he could probably do nothing but shut down his engine and close all valves.

2. The life of piping depends much upon the conditions under which it is used. If no acid or air came in contact with steel pipe, it would last almost indefinitely. Some set the limit of life of cast-iron pipe for brine circulation at from 2 to 10 yr., others at from 5 to 20.

3. The life of direct expansion piping is usually taken as from 5 to 20 yr., depending upon the conditions of its use.

4. The safety valve on the discharge line of an ammonia system should be set and sealed at 300 lb. pressure.

5. The effect of using brine instead of water for cooling a condenser would be to shorten considerably the life of the condenser. There would be nothing gained by this procedure, as a greater amount of deposit would be formed by the brine than by water and less heat would therefore be abstracted.

Magnetic Pull Affects Armature Operation

RECENTLY, I REPLACED bearings in my exciter and at the time checked the bearings for proper length and to see that the exciter was level, in perfect alinement and that the chain driving the exciter was not too tight. All of the brushes on the exciter and collector rings were renewed. The bearings seemed to run sufficiently free.

At slow speeds the armature floats but at high speed. it does not. The exciter is compound wound and part of the compounding is cut out. At all times at high speeds the armature works over to the commutator end causing that bearing to run hot. I have tried blocking this end bell out a little to see whether that would help but it did not.

This is a Westinghouse direct-current, 15-kw., 125-v., 120-amp. exciter. Its generator is a Westinghouse 312-kv-a., 480-v., 376-amp., 60-cycle, 3-phase, 95-exciting volt alternator. L. P. T.

A. Your description indicates that your bearings are not properly located with respect to the generator field. That is, they hold the armature out of its magnetic field center so that, when the field is fully excited, the magnetic pull draws the armature toward the commutator end and thus prevents it from floating in the field. You state that you have tried blocking the end bell out without benefit. Perhaps you did not get the bearing out far enough.

In case you cannot move the bearing, it may be possible to turn down the shoulder on the shaft, thus permitting the shaft to go further into the bearings and let the armature seek its magnetic center.

Feedwater Heater Selection

WHAT TYPE of feedwater heater, open or enclosed, is recommended for a plant composed of the following: Three 110-hp. Geary horizontal water-tube boilers. Steam is used for heating, pumping and process. Condensate from heating system is pumped back into boilers; 100 lb. is carried on boilers and 5 lb. on heating system. No corrosion in boilers but it is found to be quite bad in return system. Little scale in boilers. I. W. O.

A. From the statement of your conditions, it would appear that the open heater would best serve your purpose because, since you have corrosion in the return system, it would appear that this is due to entrapped oxygen, hence deaeration is necessary. An open heater functions, in part, as a deaerator hence it would tend to reduce corrosion. We presume that exhaust steam from the pumps is used for the heater.

Piston Packing Causes Noisy Pump Action

MY FEEDWATER PUMP is very noisy at times, i.e., it speaks and howls badly in the water cylinders when the pump runs at certain speeds and mostly when the make-up water is quite hot, it seems. This is a duplex steam-driven pump. Is there any remedy for this condition? I. W. O.

A. The trouble with your pump lies probably in your piston packing, valves or valve springs. You should use a hard rubber valve. It would be best probably for you to order new piston packing, new hard rubber valves and a new set of springs from the manufacturer and replace them until the noise is sufficiently eliminated.

Editorial Comment

What's Ahead?

Survey of business conditions in all fields, which has recently been made by the editors of business and technical papers, shows a favorable outlook for the future, especially for the power industry. For the first 6 mo. of 1929, not only has the general consumption of electricity risen some 5 per cent, but, in all lines of manufacture, power-driven machinery is gaining in use. Industry increased its power consumption 15 per cent over the first 6 mo. of 1928.

As a result of greater power use, production per worker and returns to the worker have increased while reemployment of workers has been sufficient to prevent rise in unemployment.

In the power field, mergers, interconnection and increase in large base-load stations is working toward greater economy, availability and reliability of electric power. Also the extension of service to rural customers in small vilages and on farms is making satisfactory progress. This has, as it developed, tremendous possibilities in improving living conditions on farms, in making possible less laborious yet more efficient methods of carryng on farm operations and in increase of load with improvement of load factor on power stations.

With the wider availability of public utility power, there is less construction of small and uneconomical industrial power plants. But where individual plants are shown to be good policy, better plants are being built. The whole power industry is coming to a basis of sounder engineering as to both general policy and details of equipment for power generation and use.

With better understanding of its advantages, the use of power wherever possible to replace human muscle, is sure to progress rapidly. With intelligent decision of each case on its merits as to central, group or individual plant generation and coördination of these methods where desirable, power costs will be reduced. Both factors will help increase the growth and importance of the power field and the opportunities it offers to those who fit themselves to meet its advancing requirements.

Alloys and the Power Plant

Much of the progress in power plant efficiency which has been made during past years is due directly to the development of metals for specific purposes. A definite start was made in this direction when Babbitt discovered the alloy that bears his name and applied it to the lining of bearings. Brass has long been used for piping and fittings where corrosion was experienced with iron and steel. During more recent years, however, chromium, molybdenum, manganese, silica, aluminum, nickel, tungsten, cobalt and other elements are being used with steel in various proportions to impart to the product the qualities needed to fit it for some specific service.

Designers of power plants have demonstrated that steam at extremely high pressures and high temperatures would be most economical under certain existing conditions but the limiting factor at the present time is the temperature at which present boiler steel begins to lose its strength. Just what the solution to the problem will be cannot be stated at the present time but we have no doubt that some form of alloy steel will be developed to meet the desired conditions.

In boiler steel, sulphur has a deleterious effect. This today, however, is overcome by using manganese as an antidote. Manganese also gives strength and toughness to the steel. Silica is playing its part in raising plant efficiency by improving the magnetic qualities of steels used in generators and motors. Castings of 15 per cent silica have been found to resist the corrosive effects of acids and gases. For springs, silico-manganese steels are finding favor. Chromium plays an important part in giving the proper quality to ball bearings and in correct proportions makes steel stainless. Rustless iron that will take a high polish is the result of combining chromium, nickel and iron in an alloy.

Corrosion, erosion, cavitation, crystallization, scaling, warping, creeping are some of the failures due to the particular purpose for which metals are used. Inasmuch as many alloys have been developed to solve definitely some of the most perplexing problems of the power plant, engineers are continuing to look to the metallurgist for metals that will not fail under any desired operating condition.

A New Form of Industrial Central Station

Announcement of the formation of a corporation to erect in the stockyard and manufacturing district of Chicago a large central power plant of about 100,000 kw. capacity, using fuel produced by a low-temperature carbonization plant, has aroused great interest in the power plant world. It represents one of the first attempts that we know of to coördinate the production of fuel and by-products by low-temperature carbonization with the production of power and other industrial services in a plant designed and operated with that specific object in view.

Not long ago, attention was called in these columns to the possibilities and advantages of the industrial central station or block plant for a group of carefully selected industrial plants. It was pointed out that such a scheme would have to be based on a carefully made engineering heat balance and an exhaustive financial analysis. But such analyses, which have been made for actual projects, have shown that the scheme is feasible under the proper conditions.

Preliminary reports of the plan for the plant at Chicago, referred to above, indicate that it will supply electric power, steam and gas for industrial use and, it is estimated, will bring about large reductions in the costs of these items and, in consequence, reductions in manufacturing costs. Whether the complete block plant idea of supplying all services will be worked out, even

to the furnishing of hot and cold water and refrigeration, is not known at present. The most striking feature of the project is the coördination of the carbonization plant with a power plant, a scheme that has been advocated for a long time.

It should not be inferred that this new combination power plant and coal-processing plant for Chicago will promptly start a trend that will put all industrial power plants out of business. This particular project has been undertaken only after a most exhaustive analysis of all the economic and engineering factors. There may be other congested manufacturing districts in some of our larger cities that will be able to profit by the experience of Chicago. But in relation to the total number of industrial power plants needed throughout the country, the number of combination power and low-temperature carbonization plants and the number of block plants will probably be in the minority for some time to come. It seems to be the tendency of industry at present to expand away from the congestion of the large cities and that tendency has a most intimate relation to the entire power development of the nation.

Nevertheless, the new project at Chicago will be carefully watched by industrial and central station engineers alike. It should yield data of the highest value to the power plant designer and operator.

Off Duty

Most members of the genus homo sapiens, no doubt, consider themselves infinitely superior to members of the genus amoeba and in point of size and noise perhaps they are correct. As to their relative importance in the Universe, however, the amoeba probably have opinions of their own and these opinions, no doubt differ considerably from those of man.

The amoeba is a curious animal. Despite his smallness and simple structure, he makes the most of his opportunities—something which cannot always be said of man. Without mouth he eats. Without muscles, brain, nervous system or sense organs he travels in the direction of his food. He could hardly understand mathematics, yet, as pointed out recently by Charles Riker in the Electric Journal, he has learned to overcome limitations imposed upon him by nature by the practical application of a certain law of geometry. This law states that the surface area of a solid increases with the square of linear dimensions but the volume increases with the cube.

When the amoeba grows, soon his outside can no longer provide for his inside and he is in danger of starving to death. But no—the amoeba apparently knows his geometry for he has solved the problem in a clever manner. Euclid himself couldn't have done better. The amoeba bisects himself thus making two. The two amoeba now again grow to comply with this inexorable law.

Thus it is seen that the amoeba, knowingly or not, is affected by mathematical laws. How true this is of ourselves we little know but we suspect that it is true to a considerable extent.

For mathematics seems to be at the root of everything. As long as our knowledge of biological processes was confined to only the most elementary facts, most life processes could be explained without mathematics, but today, as our knowledge increases, more and more does the biologist turn to mathematics. Our future textbooks on biology, no doubt, will contain as many equations as do our electrical and mechanical textbooks today.

Mathematics has long been the favorite tool of the astronomer and the physicist and within our own lifetime, the accomplishments of such organizations as the General Electric Co., the Westinghouse Co. and the American Telephone and Telegraph Co. have been based almost entirely upon the consistent application of this science. The practical development of long distance telephony, and the Orthophonic Victrola are the direct results of the application of mathematics.

Today industry in general recognizes its dependency upon mathematics and support mathematical research to a considerable extent. The engineer or chemist today who wishes to reach a high level in his profession knows that in order to do so he must be highly proficient in mathematics. Buildings and bridges of the present day are built not only on foundations of steel and stone but on foundations of mathematics as well. Every girder, every truss must be tested by mathematics before it can be hoisted in place.

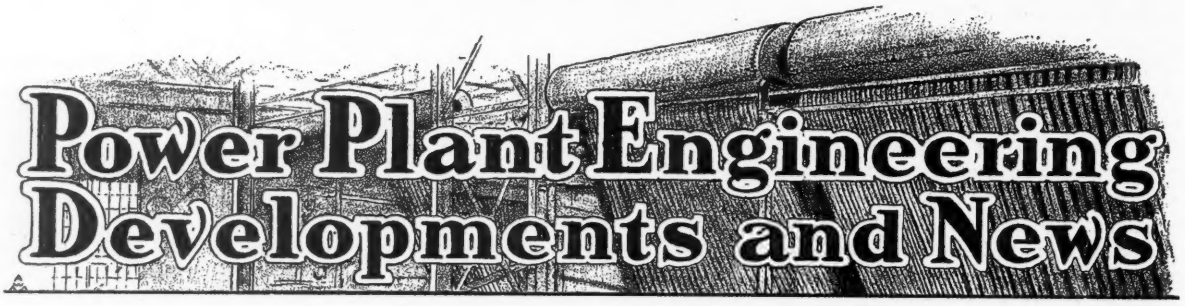
While a comparatively small group of scientists are thus building a new world, indeed a new universe, out of mathematics the layman knows little or nothing about this science. To him mathematics of even the simplest kind is very much of a mystery and when he encounters an equation, he regards it much as would the amoeba we started to discuss. Mathematics to him is just something to be learned at school or college and then forgotten as quickly as possible. And he forgets with terrible effectiveness.

The real knowledge of the world is thus in the hands, or rather in the minds of a few—those who understand the language of mathematics—and it probably will remain so. Already, the layman who wishes to keep up with modern thought is restricted to the use of the most elementary books, for if he goes to the more advanced works, the sources of really sound information, he at once finds his progress barred by an entanglement of mathematical symbols which have no more meaning to him than so much Sanskrit. He can form no conception of the modern world or of the structure of matter because these today, are explainable only in that strange language called mathematics, which takes half a lifetime to master and which no man can render into plain understandable English.

Thus is seems as though from now on, the average man must forever remain cut off from the knowledge of the amazing and thrilling doings of the learned world about us simply because they can only be described by mathematics. These are those who advocate more stress on mathematics in our educational institutions but this, considering the general run of human beings seems rather hopeless. It is hardly possible that more than a few have minds capable of grasping the higher branches of mathematics.

The average man, therefore, is not greatly unlike the amoeba. His biological processes are governed by mathematical laws as is the Universe in which he lives, but as to understanding these laws and the manner in which they operate, he is as much in ignorance as the amoeba.

Perhaps the amoeba's opinion is correct.



Diesel Power Discussed at Penn State

National Meeting of the Oil and Gas Power Division of the A. S. M. E. Initiates Improvements of Outstanding Character

MORE SUCCESSFUL than even the first national meeting which was held there last year, the second national oil-power meeting held at The Pennsylvania State College, June 24 to 27, by the beauty of its surroundings and the delightfulness of its accommodations, demonstrated the advisability of holding meetings of this character and presaged an annual return to central Pennsylvania for the discussion of this particular topic.

Low Speeds for Heavy Continuous Service

Following the address of welcome by Dr. R. D. Hetzel, president of The Pennsylvania State College, the technical session opened with a consideration of high speed developments, which was the keynote of the first two sessions. The first session, held Monday morning, was presided over by Charles L. Lawrence, President, Wright Aeronautical Corp. High Speed Oil Engine Design, by Otto Nonnenbruch was the first paper presented. In this, the author analyzed the designs of a number of engines, presenting three tables for comparison. He felt that the high speed tendency had been overdone and that the future held much for the low speed engine, running at speeds under 1000 r.p.m., especially for continuous heavy load service. Increased speed, he pointed out, can be obtained only through improved combustion and fuel-injection devices.

In the discussion which followed, E. Nibbs suggested that a formula be adopted for proper classification of engines and that the heat released by combustion per square inch of piston face area be used as the criterion by which to judge engines. Another formula includes the m.e.p., number of cylinders, stroke, bore and r.p.m.; the product of which, divided by the weight, gives 40,000 for some high speed oil engines, 38,000 for high speed gas engines and 400,000 for aviation gasoline engines. In his opinion, the two-cycle engine will be the one used by future high speed engines. P. B. Jackson, speaking on Alloy Pistons for High Speed Engines and their effect on inertia force, gave his opinion that aluminum pistons would always be necessary on high speed engines because of the higher heat conductivity of aluminum over iron. C. S. Moore presented the effect of varying injection tube lengths and E. J. Kates compared two and four-cycle displacement.

Turbulence of Charge Aids Combustion

In his paper on High-Speed Oil Engine Pumps & Injection Valves, J. L. Goldthwaite brought out the fact that although it had long been believed that high speeds were not possible in Diesel engines, it has been found that oil engines can be speeded up to a considerably higher speed than that normally required of gasoline engines and that efficient combustion has been attained in engines running at speeds higher than 200 r.p.m. He also showed that the amount of atomization necessary depended materially upon the turbulence of the charge. Contrary to usual conceptions, he showed that injection valves have a tendency to run cooler at full than at lighter loads because of the cooling effect of the incoming charge. The design of the fuel system is closely related with the design of combustion chamber, he said.

Among those who discussed this paper, D. O. Barrett spoke of the importance of using lapped oil pumps. He recommended using a secondary pump to deliver oil at 4000 lb. pressure to the injection pump. C. R. Alden stated that plunger leakage was due to grit in the oil and recommended that engine builders should specify fuel oil on the basis of viscosity and not gravity, especially with high speed engines where surface tension of fuel is very important. L. M. Goldsmith spoke on methods of preventing corrosion of plungers and W. F. Joachim, on the metallurgy of pump and spray parts.

At the second session, presided over by G. W. Lewis. W. F. Joachim, under the head, High Speed Oil Engine Combustion, presented a critical survey of the physical and chemical factors controlling conbustion in the high speed engine. This was discussed from both mechanical and chemical standpoints. This paper was very theoretical, the attempt being made to justify logical deductions by certain observed phenomena. The author likened each oil particle to a comet whose tail was made up of a cloud of widely separated oil molecules. In discussing this paper, J. B. Frauenfelder brought out the superior fuel economy of opposed piston engines.

Compactness of Diesel Plant Advantageous

Under the head, Commercial Applications of High-Speed Oil Engines, C. H. Gibbons presented applications of principally small Diesels to a large variety of services. He indicated the high speeds now being attained, pointing out one application in which the engine ran 2500 r.p.m. Emphasizing the compactness possible, an application of a Diesel engine direct con-

nected to an 18-kw. generator was cited in which the entire space occupied by engine and all accessories was 8 by 10 ft. which were installed in a basement whose head room is only 7 ft. 2 in.

Particularly for use in driving such apparatus as excavating machines, in its uniformly rising torque with decreased speed, the Diesel electric type of power appears to have advantage over all other types as will be seen in Fig. 2. In this service, torque is equally important with power.

Neglect of the important need for complete and correct power plant layout was emphasized in the first paper presented at the third session which was presided over by H. A. Pratt. In this paper, which was presented by E. J. Kates under the head, Modern Refinements in Diesel Power Plants, the author discussed the many refinements that are available for Diesel power plants and which are needed to give full value to this power. He called attention to lubricant reclaiming, to cooling water treatment, fuel oil centrifuging, elimination of objectionable noises and shaft vibration and to utilization of waste heat.

This paper brought forth a lively discussion and led to the desirability of the establishment of a subcommittee to study the accessory problem. Among those who discussed this paper, W. K. Gregory brought out the importance of air filtration, showing wear of parts to be much greater where unfiltered air is used than where the air is filtered. He also discussed various types of air filters and their applications. An air filter, he said, should have a capacity of 7 cu. ft. per min. per hp. rating of the engine. Automatic or self-cleaning filters were recommended for large installations but these, he said, were too costly for small plants.

Accessory Equipment in all Plant Bids

R. L. Howes spoke of the danger of omitting proper accessory equipment from Diesel plant bids and W. A. McGill, of the importance of centrifuging fuel oil. H. H. Maxim, in speaking of noise elimination, stated that it is apparent that by far most of the bad feeling existing against the Diesel engine is due to improper treatment or neglect in using such relatively small details as accessories. In locations where noise is at all objectionable, both exhaust and intake should be silenced. Disturbing vibrations, he pointed out, are frequently due to pulsations of either exhaust or intake or both.

FIG. 1. BEFORE THE SCHWAB AUDITORIUM—A BREAK IN THE PROCEEDING

Dean R. L. Sacket presented observations of a number of Diesel plants which clearly indicated the need of accessories. Another paper presented at this session was Some Results of the Penn State Oil Spray Research by K. J. DeJuhasz.

Cost Analysis Is Important Step

Costs were discussed at the fourth session at which R. H. Bacon presided. The Report of the Costs Committee, presented by Franz Eder was an analysis made of 27 plants from which questionnaires had been re-

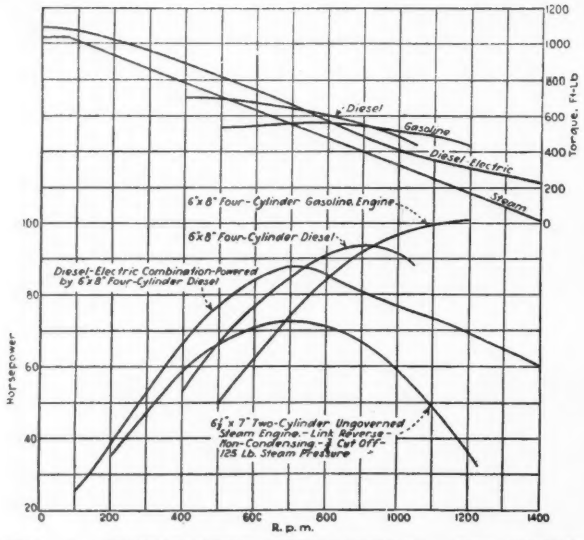


FIG. 2. COMPARATIVE SPEED-TORQUE AND SPEED-POWER CHARACTERISTICS OF DIESEL-GASOLINE, DIESEL-ELECTRIC AND STEAM-DRIVEN EXCAVATING MACHINES

turned. This report brought forth much discussion. It represents an important step toward providing a definite basis for analysis and comparison of Diesel power with other motive powers and will be abstracted at some length in a subsequent issue.

Maintenance and Repair of Marine Diesel Engines, which was presented by Louis R. Ford, was another paper that proved to be of special interest because methods used in the marine repair work described are also applicable not only to stationary Diesel practice but also to steam engine repair. This paper will also be abstracted at length in a later issue.

At the banquet, held Wednesday evening, at which Dean Sackett acted as toastmaster, Prof. A. J. Wood made the opening address which was followed by an amusing and instructive talk on the early American development of Diesel engines by L. H. Morrison. This affair was lightened by the presentation of golf prizes to the various winners of the golf tournament and of a camera to Prof. Hechler, chairman of program and arrangements, for the splendid work he has done, not only in arranging this and former oil power conferences but also for his work in behalf of Oil Power Week.

Standardization was the theme of the last session held Thursday morning at which L. M. Goldsmith presided. The first Progress Report of the Special Research Committee on Diesel Fuel Oil Specifications appointed by the A. S. M. E. was presented by Wiley H. Butler and provoked a lively discussion.

Standardization of Oils Proposed

Suggested specifications based upon analysis of replies returned from questionnaires sent to manufacturers of oil engines and to producers of oil throughout the world for both heavy and light duty were presented as in the accompanying table.

Specific gravity or "API," it was pointed out, is of no importance as pertains to the burning qualities of an oil. It should be stated, however, by the supplier in order that weight per gallon can be computed.

Oil companies which have offered to supply any

	Heavy Duty Engines	Light High Speed
Viscosity at 100 deg. F. (Saybolt Univ.)	Max. 200 sec.	Min. 45 sec. Max. 10
Sulphur		Max. 2%
Conradson carbon	" 3% by wt.	
	" 4%	" 1%
Ash	" 0.08%	" 0.02%
Flash test	Min. 150 deg. F.	Min. 150 deg. F.
Water and Sediment	Max. 1%	Max. 0.5%

engine manufacturer or large user with samples of oil at the proposed specifications so that they may make a report of running conditions to the committee, exhibit splendid coöperation in furthering the cause of the Diesel industry.

Definition of each quality of an oil and the committee's reason for adopting the limits given are included in the report. Regarding Conradson carbon, the report states that there are certain Diesel engine manufacturers who put a great deal of store in the percentage of residue carbon in a Diesel fuel, while others do not understand the term. The committee feels that considerable research work should be done on this subject, as it is not positive that high carbon content or low is responsible for unsatisfactory fuel, consequently the percentages which have been set are open to discussion. Ash is given as the most detrimental quality in

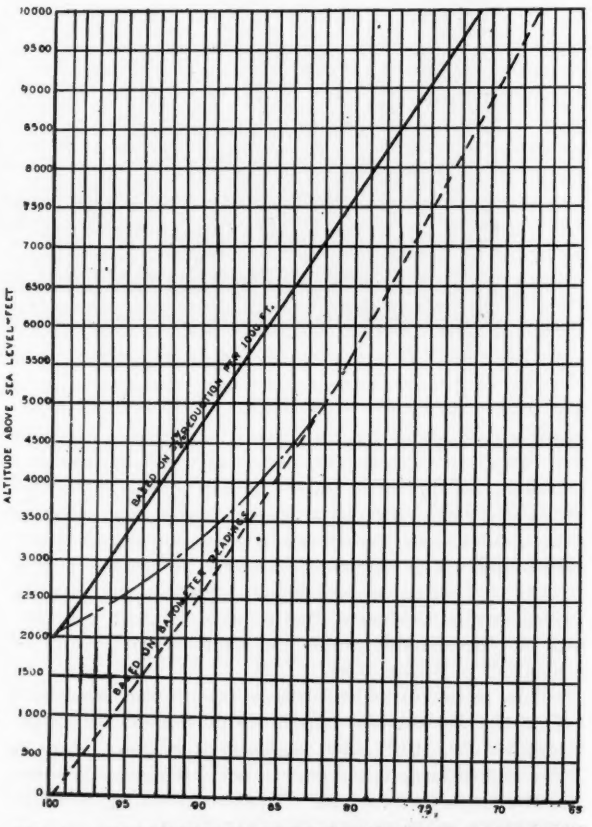


FIG. 3. RECOMMENDED CORRECTIONS TO BE MADE FOR DIFFERENT ALTITUDES

any internal combustion engine fuel and is responsible for excessive wear and premature engine failures.

Among those who discussed this paper are R. Haskell, who spoke of cases of specification failure; W. H. Butler, who suggested popularizing oil specifications by using them; L. R. Ford, who pointed out the danger of price rise due to fuel standardization and J. Kuttner, who deplored the inadequacy of data for specifications and referred to the gum test.

Bases for Oil Engine Rating Standardization

H. E. Brelsford submitted as the last paper, a discussion on Standardization of Oil Engine Ratings, in which the members displayed keen interest. The author advocated consideration of two classes of service, continuous and intermittent, when rating engines, as is done in rating electrical machinery. The materials at present used in Diesel engine construction have quite as definite temperature ratings as have insulating materials in electrical machinery and the possibility of rating a given engine is quite clearly a matter of temperature and of heat absorption. Two and four-cycle performance were compared and correction for altitude discussed. Under this head, it appeared that the only fair way is to rate engines in such a way that under all circumstances the builder will be giving the customer exactly the power that is stipulated, with an additional possible safe capacity of 10 per cent over this amount for all conditions.

Ratings offered, it is proposed, based as they are on the mean indicated pressures, are to be considered as maximum and the following are recommended:

Type Engine	Max. Indicated Press. Lb.
4-cycle, air injection	105
4-cycle, mech. injection	100
2-cycle, air injection	95
2-cycle, mech. injection with excess scavenging air	90
2-cycle, mech. injection with 1 to 1 ratio or less scavenging air	70

It is also recommended that corrections for altitude up to 10,000 ft. be based on the effect of barometric pressure on the indicated output at sea level, excepting that no correction be made from sea level to 2000 ft. and that the correction curve of 2000 to 5000 ft. be faired into the theoretical at 5000 ft. as shown in Fig. 3.

Not the least profitable, of all the splendid features of this meeting, was the ample opportunity given, through the recreational periods which were scheduled, for interchanging ideas and discussing particular features of the conference with individual members who were particularly interested in those features.

Tax of $30,209 was recently paid by the Sioux City (Iowa) Gas & Electric Co. to the city, two per cent franchise tax upon gross earnings for the period of $1,510,472, as against $1,382,750 a year ago. Itemized statement for the first half of 1929 showed gross from the electricity sales, $1,036,044; gas $365,399 and steam heat, $109,040. The Sioux Service Co., the traction interest, paid $7744 tax on $387,218 gross as against $8124 a year ago upon $406,200 gross.

Michigan Gas and Electric Men Meet at Mackinac Island

Gas and electric men of Michigan gathered at Mackinac Island on July 1 for the annual three-day conventions of the Michigan Gas Association and the Michigan Electric Light Association.

Speakers at the joint session of the two associations, which marked the opening, were Mrs. Siegel W. Judd, Grand Rapids, president of the Michigan League of Women Voters; W. J. Hagenah, Chicago, vice-president of Byllesby Engineering and Management Corp.; Oscar H. Fogg, New York, president of the American Gas Association; A. C. Marshall, Detroit, vice-president and general manager of The Detroit Edison Company; and Arthur W. Stace, Ann Arbor, director of the Michigan Committee on Public Utility Information.

Speaking upon Public Utility Regulation and Its Accomplishments, Mr. Hagenah declared that the savings which have been effected in the cost of producing and distributing electrical energy have been transmitted to the public through the constant downward revision of rates. At no time, he said, have the state regulatory commissions permitted rates that yielded an unreasonable return on the fair value.

Mrs. Judd, in her address upon The League of Women Voters and Its Interest in Electric Power, said that increasing consideration of domestic rates and the extension of domestic use of power on the part of utility leaders was most encouraging. Mr. Stace, whose subject was Public Relations and Public Opinion, declared that abundant electric power and abundant gas furnished to Michigan at reasonable rates have been among the foremost forces contributing to the outstanding progressiveness and leadership of the state in industry, in standards of living, in civic advancement, and in culture.

The second day's program of the convention was devoted to farm electrification and to the annual address of President Howard Pett, Consumers Power Co., Jackson. Prof. H. J. Gallagher, Michigan State College, told the delegates that progress in farm electrification in Michigan in 1929 will eclipse the combined progress of the twenty preceding years. The bringing of electric power to more than 10,000 Michigan farms this year will involve a total expenditure of about $5,000,000 and the building of more than 1500 mi. of farm electric service lines, he said. L. C. Moore, holder of the farm electrification fellowship at State college, described research work being carried on in the development of electric hay hoists, all-electric brooders, automatic chicken feeders and poultry house cleaners, and electric ventilation in poultry houses and barns.

Fred W. Bagnall, The Detroit Edison Co., and F. W. Pollock, for Consumers Power Co., Jackson, told of the use of steel-core wire—surrounded in one case by aluminum, in the other by copper, for the conductor—to make possible the use of longer spans between poles, to reduce the cost of electric distribution lines for farm service. With the aluminum-steel wire, Mr. Bagnall said, spans of 300 ft. between poles are now standard for his company, compared with standard residential practice of 150-ft. spans using copper wire. Digging machines mounted on motor trucks—capable of digging

a 24-in. hole 5½ ft. deep in from 2 to 6 min., according to the soil—also have helped make possible the building of cheap, reliable farm service lines.

E. M. Burd, Jackson, of Stevens and Wood, Inc., in presenting the paper on costs of generating electricity, emphasized that old mill-ponds and other small water power projects not only are of no value to the modern electric system but would be a distinct liability.

"The present mechanical and scientific age, with its cheap transportation of energy and material things, together with remarkable advances in the generation of electricity from fuel, has to a large degree, superseded these old water powers and reduced their economic value to a negligible quantity," he said. "The local mill power project rarely can be worked into the present day power system. The cost of developing a small power and tying it in with the up-to-date utility transmission system is about the same for the creek that supplied the old grist mill as for a river ten times its size and yield in energy."

Phelps Vogelsang, forester of the State Highway department, told of the program of the department in beautifying the highways, not simply as a matter of esthetic pleasure, but as a business proposition to promote the state's tourist industry. He commended the policy of utilities in employing skilled men to trim trees.

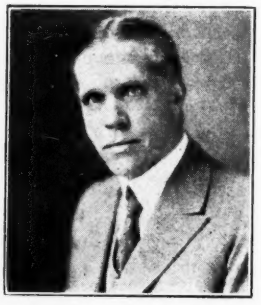
Off Peak Water Heating by Electricity was discussed by R. R. Clark, of Consumers Power Co., Jackson; and J. C. Langdell, of the same company, presented a paper on Outdoor Meter Installations, with discussions by W. A. Wadsworth, Traverse City, general manager of the Michigan Public Service Company and A. S. Albright, The Detroit Edison Co.

Officers Nominated for A. S. M. E.

NOMINATING COMMITTEE of The American Society of Mechanical Engineers presents the following nominees for the offices of the Society for 1930: President, Charles Piez, Chairman of the Board, Link-Belt Co., Chicago, Ill. Vice-Presidents, Paul Doty, Chairman of the Board, Minnesota State Board of Registration, St. Paul, Minn.; Ralph E. Flanders, Manager, Jones & Lamson Machine Co., Springfield, Vt.; Ernest L. Jahncke, Assistant Secretary of Navy, Washington, D. C.; Conrad N. Lauer, President, Philadelphia Gas Works, Philadelphia, Pa. Managers, Harold V. Coes, Ford, Bacon & Davis, New York, N. Y.; James D. Cunningham, President, Republic Flow Meters Co., Chicago, Ill.; Clarence F. Hirshfeld, Chief, Research Department, Detroit Edison Co., Detroit, Mich. American Engineering Council Delegates, L. P. Alford, Vice-President, Ronald Press, New York, N. Y.; Thomas D. Campbell, President, Campbell Farming Corporation, Hardin, Mont.; William B. Ferguson, Production Manager, Newport News Shipbuilding & Drydock Co., Newport News, Va.; Charles E. Ferris, Dean Engineering, University of Tennessee, Knoxville, Tenn.; John Lyle Harrington, Consulting Engineer, Harrington & Cortelyou, Kansas City, Mo.; William H. Kenerson, Professor of Mechanical Engineering, Brown University, Providence, R. I.; John H. Lawrence, Vice-President, General Manager, Thomas E. Murray, Inc., New York, N. Y.; Richard C. Marshall, Jr., Sumner Sollit Co., Chicago, Ill.; Charles Piez, ex-officio; A. A. Potter, Dean Engineering Schools, Purdue University, Lafayette, Ind.

Charles Piez, nominated for the presidency of the A.S.M.E., received his degree of E.M. at the School of Mines, Columbia University, in 1889 and in the same year entered the engineering department of Link-Belt Co. at Philadelphia. He became successively chief engineer, general superintendent and general manager of that company. In 1906, he was elected its president and held that office until 1924, when he was elected chairman of the Board of the company, the position he now holds.

From November, 1917, to December, 1918, Mr. Piez was vice-president and general manager of the Emer-



gency Fleet Corp. and a director general of the corporation from December, 1918, until May, 1919. He is president of Nugent Steel Co., director of several banks and has twice been president of the Illinois Manufacturers' Association. He is a member of the A. S. M. E., A. I. M. E., W. S. E. and of other technical and social organizations.

N. E. L. A. Section Chairmen Appointed

M. S. SLOAN, president of the National Electric Light Association, has announced the appointment of the four National Section Chairmen for the administrative year 1929-1930. They are: for Accounting National Section, W. R. Emerson, Oklahoma Gas and Electric Co., who succeeds J. F. Ford of the Philadelphia Electric Co.; for Commercial National Section, Marshall F. Sampsell, Illinois Public Service Co., reappointed; for Engineering National Section, Alex D. Bailey, Commonwealth Edison Co., who succeeds E. C. Stone, Duquesne Light Co.; for Public Relations National Section, Harry Reid, National Electric Power Co., who succeeds J. F. Owens, Oklahoma Gas and Electric Co.

Mr. Emerson, the new chairman of the Accounting National Section, has been associated with public utilities in Oklahoma since 1905 and since 1917 has been secretary, treasurer and general auditor of the Oklahoma Gas & Electric Co. He has taken an active part in the work of the Accounting Section of the N. E. L. A.

Mr. Sampsell, a graduate of the University of Chicago in 1896 and of the Chicago College of Law, began his public utility career in 1903 as receiver for the Chicago Union Traction Co. and other affiliated companies.

He is now a director of the Middle West Utilities Co. and president of the Central Illinois Public Service Co. and Wisconsin Power & Light Co. He is vice-president of the N.E.L.A. and during the past year has been chairman of the Commercial National Section.

Alex D. Bailey, the new chairman of the Engineering National Section, was born in Wisconsin in 1882 and has lived in Chicago since the age of seven. After graduating from Lewis Institute, he worked for the Evanston Heating Co. and entered the employ of the Chicago Edison Co., (a predecessor of the Commonwealth Edison Co.) in 1903 as mechanical engineer at the Harrison St. station. He was later transferred to the Engineering Department of the company. In 1906 he was sent to Fisk St. station as assistant chief engineer and later became chief engineer of this station. On January 1, 1921, he was appointed superintendent of Generating Stations of the Commonwealth Edison Co., which position he now holds. He is author of numerous articles, has served on various committees of the Commonwealth Edison Co. and has been vice-chairman of the Engineering National Section and Counsellor of the Prime Movers Committee of the N.E.L.A. He is a member of the Main Research Committee of the American Society of Mechanical Engineers.

Mr. Reid, new chairman of the Public Relations National Section, has been connected with public utility companies in Kentucky and the middle west for 20 yr. In 1917 he became president of the Interstate Public Service Co. and in 1927 president of the National Electric Power Co.

Water Level Indicator

RECENTLY a simple device which permits the placing of water level indicators at any desirable location or elevation has been put on the market by Combustion Engineering Corporation, New York.

Figure 1 shows how this water level indicator operates and why it is possible to locate it at any convenient point. The usual water column is shown connected to the boiler drum, with a non-corrodible float inside suitable for the maximum working pressure for which the boiler is designed. This float is direct-connected by means of a non-corrodible wire extending downward through a small pipe to an indicator in the water glass. The circuit around this indicator is filled with cold water which has no corrosive effect on the glass.

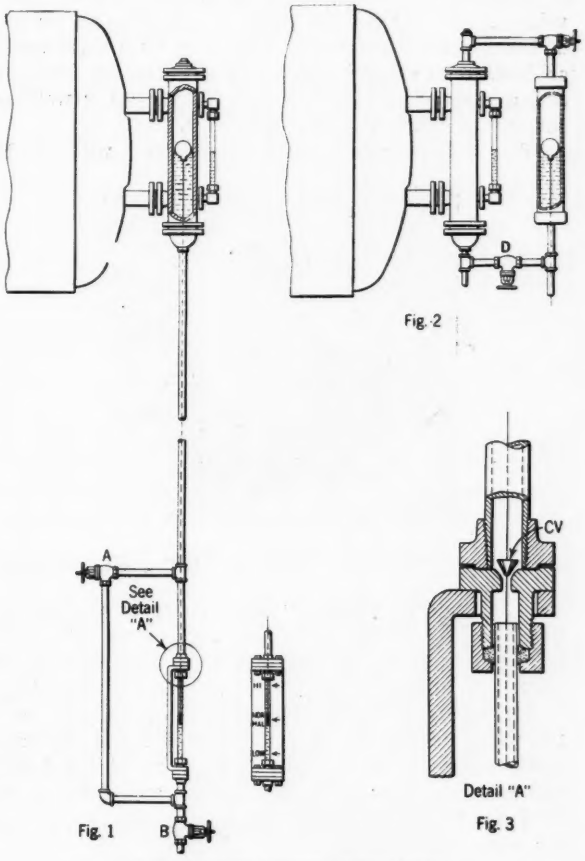
Adjustment is such that, when the float in the water column on the drum is in its normal position, the indicator within the lower glass is in the center of the glass, its normal level condition. The indicator consequently fluctuates correspondingly with the up and down movement of the water column float at the drum.

It is possible to locate the indicator to meet any local conditions. If it is not practical to drop the indicator vertically from the water column on the drum, arrangements are easily made whereby the water column can be placed inside the drum, or, as shown in Fig. 2, horizontal extensions of any length can be made to bring the water column to any desired position.

To prevent leakage in case the water glass should be broken, an automatic shut-off valve is placed in the circuit directly above the glass. This conical valve is attached to the wire between the water column and the water level indicator in such a position, as shown in Fig. 3, that when the glass is broken and the water released, the valve is forced into its seat, thus closing the cold water circuit.

After a new glass has been put in place, valve A, Fig. 1, is open, valve B remaining closed, thus equalizing the pressure above and below the valve. The float then returns to the position of the water level and in so doing, lifts the valve CV which allows the water again to fill the indicator gage glass.

Advantages of the device are its convenience and



C-E WATER LEVEL INDICATOR

that it operates in a cold water circuit, eliminating the replacing of glasses in ordinary water columns. By having cold water only, in contact with the glass, the usual round glass is suitable for exceedingly high pressures.

The C-E Water Level Indicator can be installed in conjunction with, or separate from, the regular high and low alarm signal system.

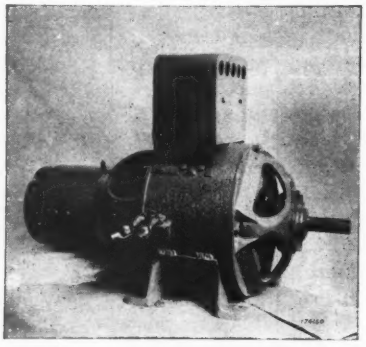
Welding Generators for Belted or Coupled Service

FOR USE in isolated places where electric power is not available and where driving power such as gasoline engines, steam engines, lineshafting, tractors, are already at hand, The Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., has recently added to its line of arc welding equipment a new design 200-

amp. generator which is not provided with a driving unit. This complete unit consists of a special constant current type SK welding generator with coupled exciter overhung from the generator bracket, control panel and reactor. The reactor is mounted separately.

The generator is differentially compound wound and designed for a single operator. The constant-current, variable-voltage characteristics of the generator together with the separately excited feature, are intended to insure a fast, steady and penetrating arc. Variations in arc length or intensity are automatically compensated for by instantaneous changes in the generator voltage. Control for the generator is mounted on top of the generator frame and protected by a sheet metal cabinet. The control consists of a voltmeter, ammeter and a single dial field rheostat for adjusting welding current over the entire current range.

The generator is rated in accordance with N. E.



WELDING GENERATOR WITH EXCITER AND CONTROLS

M. A. standards, 1 hour 50 deg. C. rise on a resistance load at 25 v. It has a welding range from 60 to 250 amp. and requires a driving unit whose maximum rating is: motor, 10 hp.; lineshaft, 15 hp.; gas engines, 20 hp.

To round out its line of welding equipment, the company has recently brought out new 300 and 400-amp. single operator arc welding generators of the belted and coupled type. Speeds of 1750 and 1450 r.p.m. clockwise and counter-clockwise rotation provide ratings for every application.

The company also announces as new equipment a 300-amp., gas-engine-driven, single-operator arc welding set. The complete set consists of a model P-35 Continental 4-cylinder gas engine direct connected to the new type Westinghouse 300-amp., single-operator, type SK, arc welding generator, with flexibly coupled exciter overhung from generator bracket of the same type as shown above. The generator has a special bracket which fits into the engine housing, to make the complete equipment as compact as possible.

Straight Line Drive for Taylor Unit

STRAIGHT LINE DRIVE for its Taylor stoker has recently been announced by American Engineering Co., Philadelphia, Pa., to meet the conditions imposed by long narrow stokers as used in large modern installations.

Figure 1 shows the application of the drive to the

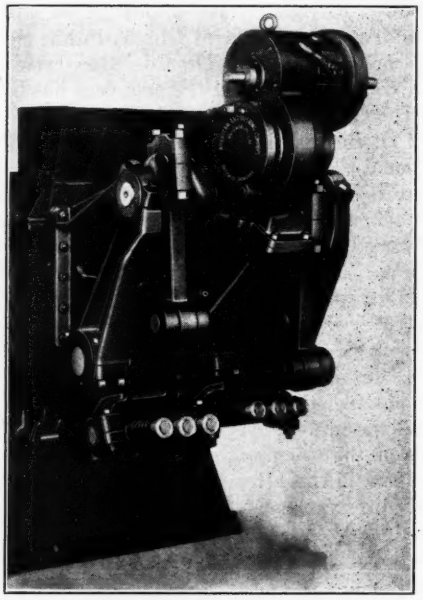


FIG. 1. TAYLOR STRAIGHT LINE DRIVE, SHOWING RODS FOR ADJUSTING PUSHERS, DRIVEN INDEPENDENT OF MAIN RAM

stoker built for Edgar Station. Drive for the coal feeding ram is entirely independent of the distributing pushers. Moreover, elimination of the direct connection between the crankshaft and the coal feeding ram, it is claimed, eliminates angular thrust and eccentric loading of the ram. The drive is designed to provide increased bearing surface to prolong life of parts and to reduce maintenance.

Additional advantages claimed as a result of use of this drive are: elimination of fine coal dust through the ram box and of hot air and dust through the glands where the pusher rod enters the wind box; smoother

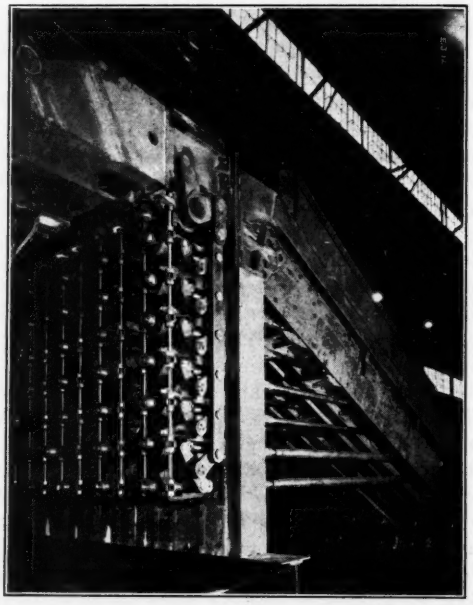


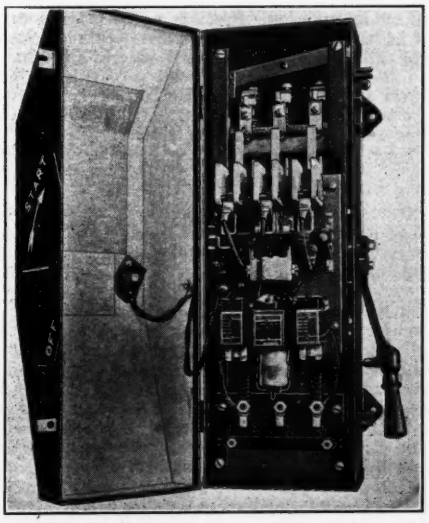
FIG. 2. TAYLOR STRAIGHT LINE DRIVE APPLIED TO STOKERS FOR DELRAY NO. 3, SHOWING INDIVIDUAL CONTROL OF PUSHERS, STEEL STRUCTURE AND HINGE JOINT

operation; saving in aisle space by use of shorter ram boxes; fewer oiling points. The crankshaft can be made in any size of heat-treated forged steel and the structure is designed to be exceptionally rugged with liberal bearing surfaces.

For the 57-tuyere stokers built for Delray Power House No. 3 of The Detroit Edison Co., a further improvement has been applied, shown in Fig. 2. In this new high-capacity drive, the stroke of each pusher can be controlled separately. Other principal features are stated by the manufacturer to be as follows: increased stroke of coal pushers; improved automatic air control to every part of the fuel bed; a hinge for vertical movement of the stoker as it expands lengthwise; provision for lateral expansion of each individual retort; gallery along stoker front at level of drive; alinement of whole stoker front on structural steel; airtight construction of front; non-clogging tuyeres.

Resisto-Transformer Starter

ALLEN-BRADLEY CO., 286 Greenfield Ave., Milwaukee, Wis., has recently developed the new Bulletin 648 resisto-transformer starter shown here. The starter is a combination of the graphite compression



STARTER COMBINES GRAPHITE COMPRESSION RESISTOR AND AUTO TRANSFORMER

resistor and the autotransformer (compensator) type of starter, for obtaining stepless acceleration with low current input. Large squirrel-cage motors, it is claimed, can be started without causing line voltage jolts or dimming lights combined in the same network.

No initial current inrush occurs, it is stated, because the compression resistors are connected in series with the autotransformer when the motor is connected to the line. These resistors permit acceleration of the motor from standstill to full speed without opening the line connections to the motor. An autotransformer is provided to reduce the line current in proportion to the transformer ratio. At full speed, the motor is connected to the line without opening the line circuit, thus preventing the second current inrush. The starter contains the usual protective features.

Flex-Mor Drive, a New V-Belt Drive

IN THE LAST few years, there has been a considerable development in the use of elastic V-shaped belts in multiple.

One of the most recent developments in V-belt drives is known as the Flex-Mor drive, a product of Fairbanks, Morse & Co. of Chicago, Ill. The new drive is the result of numerous field and dynamometer tests to determine the factors of belt angles, slippage, the life of belts of various constructions, character of the various materials entering into the drive and power capacity.

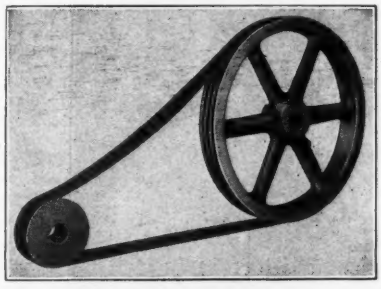


FIG. 1. A SET OF SHEAVES AND BELTS FOR A TYPICAL V-BELT DRIVE

Belts used with this drive are built up of an outer belt jacket of duck treated with rubber to improve its wearing qualities. As shown in Fig. 2, this jacket consists of two layers of duck enclosing a core made up of a layer of rubber, several layers of rubber-embedded cords and another layer of rubber above the cords. The layer of rubber below the cords is specially compounded to withstand repeated compression, while the layer of rubber above the cords is specially compounded to withstand repeated tension. The rubber-embedded cords are laid at the neutral axis of the belt where there is the least tension or compression. These cords are made of long staple cotton and the construction is quite similar

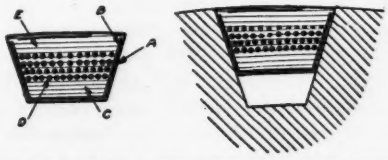


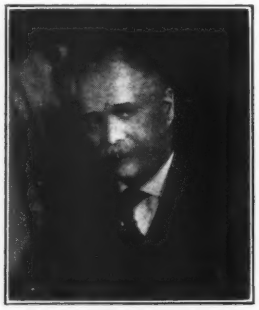
FIG. 2. DRIVE BELTS ARE BUILT UP OF DUCK, SHOWN AT A AND B, SPECIAL COMPOUNDED RUBBER (C AND E) AND LAYERS OF CORDS, SHOWN AT D

to that which is used in cord tires. The various elements of the belt are assembled in the mold and vulcanized together into a unified structure.

Sheaves are made of semi-steel and have been designed with particular reference to the angle and depth of the grooves so that the belt slippage will be a minimum. At the same time, the relation between the angles of the belt sides and the grooves is such that the belt makes a gradual contact with the grooves as it bends around the sheaves. Due to the wedging action of the belts in the grooves and to their inherent elastic qualities, there is no sudden grabbing of the load and sudden shocks to the driving and driven machines are eliminated.

Death of Thomas E. Murray

THOMAS E. MURRAY died on July 21 at his summer home at Southampton, Long Island, N. Y. He was widely known in the public utility industry as vice-president and general manager of the New York Edison Co. until its merger with other companies last year, when he became vice-chairman of the board. He was credited with a large number of inventions and with the installation of central stations with a total capacity of over 2,000,000 kw. Among these stations are the famous plants known as Sherman Creek, Hell Gate, Hudson Ave., East River and several others, as well as plants in Albany, Rochester and other New York cities.



THOMAS E. MURRAY

Mr. Murray was born at Albany in 1860, was engineer of the city water works at the age of 21 and 6 yr. later was made chief engineer of the Albany Electric Light Co. founded by A. N. Brady. In 1898, Mr. Murray was sent to New York to effect the merger of the electric lighting systems in Brooklyn. Soon after, he became second vice-president and general manager of the New York Edison Co., having consolidated several properties in this company.

Besides these and other activities in the central station field, Mr. Murray founded the Metropolitan Devices Corp. and carried on a large consulting engineering business with the firm of Thomas E. Murray, Inc. In addition, he is credited with many inventions in the fields of water-cooled furnace walls, electrical devices, under catching devices, stokers, pulverized fuel equipment, electrical transmission systems and so on.

For two years, Mr. Murray was president of the Association of Edison Illuminating Companies. He received several honorary degrees and was a member of the A. S. M. E., A. I. E. E. and other technical societies.

News Notes

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION, 420 Lexington Ave., New York, announces that it will hold its annual meeting at the Wardman Park Hotel, Washington, D. C., during the week of October 7.

MEETING OF THE A.S.M.E. is being arranged for Oct. 21 to 23 at Akron, Ohio, to cover materials handling, training for industry, aeronautics, steam power, iron and steel and management problems. Inspection trips are planned to Firestone Tire and Rubber Co., Goodyear Tire and Rubber Co. and B. F. Goodrich Co. plant.

OCT. 7 TO 12, the National Electrical Exposition will be held in Grand Central Palace, New York City, under the auspices of the New York Electrical League and the New York Electrical Board of Trade. It will be devoted to demonstrating electrical equipment and apparatus for the factory, the office and the home, their operation and advantages. International Exposition Co., Grand Central Palace, New York, is managing the exhibit.

DE WALT PRODUCTS CORP., Leola, Lancaster County, Pa., announces several improvements in its Model D woodworker designed to make possible the delivery of 50 per cent more power to the work. The Model D machine is powered by a new design of 2 or 3-phase 5-hp. motor to give greater power on full load and less temperature rise. Another improvement is the placement of the dial plate with degree markings and pitch scale right out in front of the operator for easy adjustment for angle or bevel cutting.

THE FISHER GOVERNOR CO. of Marshalltown, Iowa, recently announced the purchase of the Apex Regulator Co. of Decatur, Ill. A. W. Cash, founder of the Apex Co., has contracted to act as engineer and have general supervision of the new plant. All of the plant equipment of the Apex Company will be moved to Marshalltown.

FULLER LEHIGH CO., Fullerton, Pa., announces to all users of Chilled-Iron Products that Elverite, grade of chilled iron developed by the Fuller Lehigh Co. under the direction of J. S. Elverson, is now available. In many major industries, chilled-iron castings fill an important place. Fuller Lehigh Co. believes that a product thus known should be distinctively named and given place among the metals that have been important factors in the progress of industry and that it is fitting that recognition be extended to the work and genius of anyone contributing in an exceptional way to industrial progress through invention or development of excellence.

Therefore, it offers tribute to J. S. Elverson, who for more than 25 yr. has specialized in its chilled-casting work, by henceforth identifying all chilled products of the company as Elverite.

R. H. BACON has been made general advertising manager of Fairbanks, Morse & Co., Chicago, Ill., according to a recent announcement. Since 1925 he has been with the company, at first handling publicity in the oil engine division, later in general charge of publicity. From 1922 to 1925 Mr. Bacon was associate editor of Power Plant Engineering. Previous to that he was on the editorial staff of Electrical World and for three years had been assistant electrical engineer for the Copper Range Mining Co.

E. Y. SAYER ENGINEERING CORP., Knickerbocker Building, New York City, announces the appointment of E. P. Dillon, E. E., as vice-president and associate engineer. Since 1918, he has been general manager for the Research Corp. of New York, in charge of sales.

THE AMERICAN HOIST & DERRICK CO. of St. Paul announces the removal of its office from 139 Townsend St., San Francisco, to 5515 Doyle Ave., Emeryville, Oakland, Calif., Boyd Nixon, who was in charge of the San Francisco office, will continue in charge.

IOWA RAILWAY & LIGHT CORP. recently completed negotiations for the purchase of the farmer-owned Salem-Gladbrook distribution system which was established and has been operated 8 yr. by 60 farmers in that territory. Current was supplied by the Iowa Railway and Light Corp. and the utilities company included a more attractive rate schedule, promise of better upkeep of the lines and outright purchase of interest for cash with alternative of exchange for electrical appliances, in completing the negotiations. Other lines will be built in the territory.

ROBERT B. MARSHALL, who has spent the past 21 yr. in the conveyor business, has joined the Chain Belt Co.'s conveyor division with headquarters at the company's New York City office at 50 Church St.

LEEDS & NORTHRUP CO., Philadelphia, Pa., announces that it has appointed R. L. Sittinger, 80 Federal St., Boston, Mass., as its exclusive sales representative in New England. The company has also appointed Irvin C. DeHaven Engineering Co., State Life Building, Indianapolis, Ind., as its representative in Western Ohio, Kentucky and Indiana, except in the extreme northern portion.

CHARLES H. SCHRODER, secretary of the Murray Iron Works in Burlington, Iowa for 27 yr., died on July 29 at the age of 62, after 47 yr. of service with that company.

HAROLD S. FALK, vice president and works manager of the Falk Corporation, Milwaukee, Wis., has been appointed chairman of the committee on industrial education of the National Metal Trades Association.

JOHNS-MANVILLE CORP., New York City, announces the title of its former Railroad and Government Department has been changed to the Transportation and Government Department, according to a new sales organization plan just put into effect. George A. Nicol, Jr., vice president of the corporation, heads the new department, with C. S. Clingman as his assistant.

WESTINGHOUSE ELECTRIC & MANUFACTURING Co. announces that it recently obtained an order for the electrical equipment for the Bachman Pumping Station of the City of Dallas, Texas. The order includes eight synchronous motors with exciting and control equipment. The synchronous motors are 90 per cent leading power factor and operate from a 2200-v., 3-phase, 60-cycle line. Motors are designed with torques ample for starting the pumps under load. Three are 800 hp., 900 r.p.m.; and one is 400 hp., 1200 r.p.m.; three are 350 hp., 900 r.p.m.; and one is 125 hp., 1200 r.p.m. All are synchronous motors. All of the motors except the 125-hp., 1200-r.p.m. unit will have pedestal type bearings. This construction is to make inspection easy and will be convenient when the motor windings are cleaned and repairs made. New type of pedestal bearing with an extra wide base is used to eliminate any tendency toward vibration sometimes found in large bracket type motors. Variable speed is obtained for the pumps by varying the frequency of the line from 54 to 63 cycles. This gives a speed range of from 5 per cent below normal to 5 per cent above normal speed. Full magnetic control will be used.

CHICAGO PUMP Co., Chicago, Ill., announces that in the future its representative in Portland, Oregon, will be D. R. Munro, 201 Lumbermans Bldg.

FOR THE FIRST 6 mo. of 1929, sales billed by the General Electric Co. are reported as $194,353,307 as against $158,015,221 for the same period of 1928. Orders received during this period for 1929 were 30 per cent greater than for 1928 and profits available for dividends on common stock increased 26 per cent.

IOWA ELECTRIC Co. of Cedar Rapids has been granted 25-yr. franchise in Lost Nation, Iowa, and will begin immediate reconstruction of the distribution system in that village, having acquired the plant from Henry Dobling and Fred Daniel, who were owners and operators. The sale was conditional upon approval of the franchise and the Iowa Electric took the plant over immediately. Extensive improvements are scheduled for the fall.

STOKER SALES for June, 1929, are reported by the Department of Commerce as 203 serving 67,322 hp. of boilers, as against 174 stokers for 60,772 hp. in May and 162 stokers for 42,628 hp. in June, 1928, of the June, 1929 sales, 82 were for fire-tube boilers of 13,323 hp. and 121 for water-tube boilers of 53,999 hp.

HILLS-MCCANNA Co., of Chicago, Ill., is describing in a recent circular its line of proportioning pumps for water-softening plants and general metering of chemicals. They are for chain, lever or motor drive in various arrangements with capacities from 5 to 60 gal. per hour and for pressures up to 400 lb.

OXWELDING of aluminum and its alloys is described in a bulletin issued by the Linde Air Products Co., New York. It covers the processes for cast and sheet metal, also for the strong aluminum alloys now widely used in manufacturing.

Catalog Notes

SYNCHRONOUS VISUAL SUPERVISORY CONTROL is the subject of circular 1834, a 12-page booklet issued by Westinghouse Electric & Manufacturing Co., describing present types of supervisory control units with their advantages and methods of operation. The company has also issued leaflet 388, describing a new line of Class 12-700, type A reversing drum controllers for wound rotor and induction motors. Westinghouse steel panels for switchboards are also described by the company in its Folder 5179, while Folder 5181 discusses the advantages and features of steel switchboards.

SERIAL REPORT of the Prime Movers Committee of the National Electric Light Association, 420 Lexington Ave., New York, N. Y., on foreign developments, just issued as publication 289-64, contains statements by American engineers such as Messrs. Alex D. Bailey and Geo. A. Orrok, and by several foreign engineers, including R. H. Rosencrants, A. L. Mellanby and R. H. Andrews. Opinions are expressed on the trends of power plant developments in foreign countries and considerable information about particular installations is given by the text and illustrations. Fuel control, high-pressure steam boilers, steam accumulators and electric boilers and other equipment are discussed in some detail. There is also some comment on steam turbines and Diesel engines.

APPARENT NEED for an operating code manual outlining rules of procedure in both boiler and turbine rooms of steam generating plants has led the Prime Movers Committee of the National Electric Light Association, 420 Lexington Ave., New York, N. Y., to revise and republish in convenient form all of the previous reports of the subcommittee on Operating Code Manual. The rules contained in the previous reports were based on the comments and criticisms of questions contained in questionnaires drafted from rules extracted from the Station Operating Handbook of the Philadelphia Electric Co. As it is impossible to formulate one set of rules to fit all cases, no attempt is made to stress adherence to the sequence of the different operations: it is understood that modifications are necessary, depending upon the best judgment of the particular problems and upon the installed equipment in each individual plant. The use to which an operating code my be put, however, lies entirely in the hands of the individual engineers. It is probable that, in emergency cases, such rules will of necessity be overstepped or entirely ignored, but their very existence and the familiarity of the operator with them for normal operation will cause them to serve as a guide and promote good judgment in cases of emergencies. The value of a code of this kind is not measured by the exactness with which the rules embodied are carried out but rests, rather, upon the fact that these rules in their general make-up include all possible necessary phases of any particular operation.

COPES CONTROL VALVE for steam, water or other fluid is described and illustrated, applications shown and dimensions given for sizes 1 to 8-in. in an interesting pamphlet issued by the Northern Equipment Co., 722 Grove Drive, Erie, Pa.

LOCK JOINT Reinforced Concrete Pressure Pipe, its design, advantages and ways in which it has been installed for municipal and industrial water supply systems, are discussed in an illustrated 12-page bulletin by Lock Joint Pipe Co., Ampere, N. J.

NALCO CHEMICAL PROPORTIONERS for automatic feeding of chemical reagents and especially for proportioning service in water treatment, are described and illustrated in Bulletin 20, just issued by National Aluminate Corp., 6216 West 66th Place, Chicago, Ill. The company is also issuing as Bulletin 21, an article by J. A. Holmes on Control of Boiler Water Concentration as Related to Foaming, Carryover, Wet Steam and so on.

DRAFT GAGES, gas analysis equipment, CO_2 recorders and recording pressure and vacuum gages are illustrated in a recent series of bulletins of the Defender Automatic Regulator Co., 308 So. 8th St., St. Louis, Mo. Bulletin No. 8 covers water and motor-operated CO_2 recorders; catalog No. 10 gives in condensed form the company's line of gages, pyrometers, thermometers, water columns, feedwater and damper regulators, balanced valves, Orsat and CO_2 testers; bulletin No. 16 describes boiler room instrument board; bulletin No. 27 deals with the complete line of draft gages; bulletin No. 32 illustrates portable draft gages; bulletin No. 34 shows pointer type and multiple pressure draft gages; bulletin No. 52 is on recording and indicating pressure gages and thermometers.

DISTILLATION PRODUCTS OF COAL are discussed in publication 289-69, serial report of the Prime Movers Committee, Engineering National Section, National Electric Light Association, 420 Lexington Ave., New York, N. Y. Present status and future of the industry are discussed with comments on factors to be considered, possibilities of low temperature tar and foreign developments. This is followed by statements from various organizations interested in low temperature carbonization and allied processes, and data are presented on the work being done at Dunston, England, and Philo, Ohio, as well as at the K. S. G. plant at Brunswick, N. J. Several other processes are also discussed briefly.

MECHANICAL RELIABILITY of Hydroelectric Units, publication 289-68, has just been issued by the Hydraulic Power Committee of the National Electric Light Association, 420 Lexington Ave., New York, N. Y. This embodies the results of the fourth year's study on the subject by the Hydraulic Power Committee. The data are tabulated from the 1927 records of 134 units. For all of the classes of units, the most important principal group of causes of outage time is waterwheels and auxiliaries. The next in order is generators and appurtenances and the last, general hydraulic causes. Of the individual causes affecting the outage of the entire number of units, headgates or intake is the largest item of general hydraulic causes, with other general hydraulic causes following. In the water wheels and auxiliaries group the leading place goes to the runner, with general overhauling and replacements second. Cleaning and other causes respectively hold first and second places in the group of generators and appurtenances.

NORTON REFRACTORY MATERIALS and their uses are discussed and illustrated in a 32-page bulletin published by the Norton Co., Worcester, Mass.

CONSTRUCTION AND METHOD of operation of the C E water level indicator is shown in a folder recently received from Combustion Engineering Corporation, 200 Madison Ave., New York, N. Y. This device indicates water level for high type boilers at the eye level of the operator.

WATER WORKS system of the City of Toronto, Ont., which is now being extended by a $14,000,000 addition, is briefly described, particularly the pumping equipment, in a leaflet distributed by the De Laval Steam Turbine Co., Trenton, N. J. Altogether, there are 14 large De Laval centrifugal pumps in the several pumping stations, their aggregate daily capacity being approximately 325,000,000 gal.

Power Plant Construction News

Ala., Birmingham—The Southern Steel Works Co., Lucien Avenue, plans installation of power equipment in connection with extensions and improvements in mill, entire project reported to cost more than $100,000.

Calif., Los Angeles—The Willard Storage Battery Co., East 131st Street, Cleveland, Ohio, plans installation of power equipment in proposed branch storage battery manufacturing plant near Los Angeles, entire project reported to cost close to $850,000.

Calif., Redwood City—The Alaska Codfish Co., 142 Drumm Street, San Francisco, Calif., plans installation of power equipment in connection with proposed rebuilding of packing plant at Redwood City, destroyed by fire, July 21, with total loss estimated at $250,000.

Calif., Santa Cruz—The Union Ice Co., Santa Cruz, has plans under way for the construction of addition to ice-manufacturing plant on Chester Avenue, to cost about $50,000, with equipment. S. L. Twitchell is local manager. Headquarters are at San Francisco.

Fla., Hollywood—The City Council is said to be planning an early call for bids for equipment for extensions and improvements in municipal waterworks, including pumping machinery and accessories. C. E. Bergon is city manager.

Ill., Danville—The F. W. Amend Co., 346 West Huron Road, Chicago, Ill., plans installation of power equipment in proposed food products plant on North Griffen Street, Danville, entire project to cost about $100,000. L. F. W. Stuebe, Adams Building, Danville, is architect.

Ill., Rock Island—The International Harvester Co., 606 South Michigan Avenue, Chicago, Ill., has filed plans for a two-story boiler and compressor plant at its works at Rock Island, estimated to cost more than $125,000, with equipment.

Ind., Cambridge City—The Mal-Gra Castings Co., plans installation of power equipment in connection with proposed rebuilding of foundry, recently destroyed by fire with loss reported at $70,000.

La., Baton Rouge—The Standard Oil Co. of Louisiana, Baton Rouge, plans installation of power equipment in connection with extensions and improvements in local oil refining plant, entire project to cost more than $5,000,000.

La., Monroe—The Brown Paper Mill Co. will install power equipment in proposed new addition to mill to double present capacity, project reported to cost more than $3,000,000. George F. Hardy, 309 Broadway, New York, is engineer.

Md., Baltimore—The Black & Decker Mfg. Co., Pennsylvania, Towson, plans installation of power equipment in connection with proposed addition to electric drill manufacturing plant, entire project to cost about $150,000. George N. Mackenzie, 5 North Guilford Avenue, Baltimore, is architect and engineer.

Mich., Monroe—The Detroit Edison Co., 2000 Second Avenue, Detroit, has preliminary plans under way for a one-story power substation at Monroe, estimated to cost about $40,000.

Mich., Northville—The Northville Laundry Co., Main Street, plans construction of a one-story boiler plant in connection with new mechanical laundry, entire project to cost about $40,000. Smith, Moss & Mitschke, Penniman-Allen Building, Plymouth, Mich., are architects and engineers.

Minn., Minneapolis—The National Tea Co., 2837 Third Avenue, South, will install power equipment in proposed two-story factory addition to cost $180,000. W. E. Long, 155 North Clark Street, Chicago, Ill., is architect and engineer.

Mo., St. Louis—The Mallinckrodt Chemical Co., 3600 North Second Street, has filed plans for a one-story and basement boiler plant to cost about $80,000, with equipment.

Neb., Fairbury—The City Council has engaged the Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., engineer to prepare plans for proposed rebuilding of portion of municipal electric light and power plant, recently damaged by a tornado. Additional equipment will be installed.

Nev., Las Vegas—The National Ice Co., has plans under way for the construction of a one-story ice-manufacturing plant to be equipped for a capacity of about 30 tons per day, reported to cost $85,000, with equipment.

N. J., Atlantic Highlands—The Standard Oil Co. of New Jersey, 26 Broadway, New York, plans installation of power equipment in connection with a proposed storage and distributing plant at Atlantic Highlands, entire project to cost about $200,000. Pumping machinery will be installed.

N. J., Bloomfield—The Essex County Board of Vocational Education, Hall of Records, Newark, will install power equipment for industrial service in new Boys' Vocational School at Bloomfield, for which bids will soon be asked on general contract. Entire project will cost $650,000. Guilbert & Betelle, 24 Branford Place, Newark, are architects.

N. Y., Jamestown—The Municipal Electric Light Department, City Hall, is said to have received authority for the construction of a new addition to municipal electric light and power plant, including installation of a 12,500 kw. turbo-generator and accessories, estimated to cost about $130,000.

N. Y., New York—The Cutler-Hammer Mfg. Co., Milwaukee, plans installation of power equipment in a proposed new plant in the vicinity of New York for the manufacture of electric controls, switches, etc., entire project to cost more than $500,000.

N. C., High Point—The City Council has engaged William C. Olsen, 5 Exchange Place, Raleigh, N. C., consulting engineer, to prepare plans for a proposed municipal power plant, reported to cost close to $50,000, with equipment.

Ohio, East Liverpool—The Patterson Foundry & Machine Co., East End, plans installation of power equipment in proposed addition to plant to cost about $150,000.

Ohio Hamilton—The Champion Coated Paper Co., is perfecting plans for the construction of a one-story power plant at local mill, with capacity of about 20,000 kw., reported to cost close to $100,000, with equipment.

Okla., Oklahoma City—The Oklahoma Publishing Co., Oklahoma City, will install power equipment in proposed new printing and publishing plant in the Oklahoma Park section, entire project to cost about $300,000. E. K. Gaylord is president.

Pa., Monaca—The Pittsburgh Tube Co., Vandergrift Building, Pittsburgh, will install power equipment in connection with new plant addition to cost upwards of more than $150,000. C. O. Spillman is general superintendent.

Pa., Parker—The Wightman Glass Co., Parker, plans installation of power equipment in connection with proposed rebuilding of portion of plant, recently destroyed by fire; reconstruction will cost more than $200,000.

Pa., Philadelphia—The Girard Smelting & Refining Co., Tioga and Richmond Streets, plans installation of power equipment in connection with new plant addition on Milnor Street, entire project estimated to cost $140,000.

Tenn., Chattanooga—The Chattanooga Coca Cola Bottling Co., 214 Fort Street plans installation of power equipment in proposed two-story bottling plant to cost about $100,000.

Tenn., Knoxville—The Knoxville Structural Steel Co., H. R. Adams, president, recently organized, will install power equipment in proposed steel fabricating mill on Central Avenue to cost close to $100,000.

Texas, Baytown—The Humble Oil & Refining Co., Houston, Texas, plans installation of power equipment in connection with extensions in refining plant at Baytown for gasoline production, entire expansion to cost $2,000,000. Company is a subsidiary of the Standard Oil Co. of New Jersey, 26 Broadway, New York.

Texas, Dallas—The Bent Concrete Pipe Co., Fort Worth, Texas, with headquarters at Los Angeles, Calif., plans installation of power equipment in connection with proposed new concrete pipe-manufacturing plant at West Dallas, reported to cost more than $700,000.

Utah, Logan—The Ryan Fruit Co., has plans under way for the construction of a cold storage and refrigerating plant, reported to cost about $30,000, with equipment. S. C. Westcott is local manager.

Wis., Fond du Lac—The Giddings-Lewis Machine Tool Co., 142 Doty Street, plans installation of power equipment in proposed new plant addition to cost more than $75,000. The Austin Co., Euclid Avenue, Cleveland, Ohio, is engineer.